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Air Pollution–Associated Respiratory Morbidity and Lung Function Impairment among Urban Residents of Delhi, India

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Abstract

Chronic exposures to outdoor and indoor air pollution have been implicated to several respiratory ailments. Diseases of the lungs and the airways are often manifested by one or more symptoms that can be easily recognized. Thus, the presence of a particular symptom or a group of symptoms helps in identifying the presence of an underlying disease in respiratory organs. The study was conducted on adult residents of Delhi with age between 21 and 66 years and compared to age and gender matched rural counterparts. Air quality data was obtained from Central and State Pollution Control Boards. Additionally, real-time particulate pollutant concentration in air was measured by portable, battery-operated laser photometer. The prevalence of respiratory symptoms was assessed through questionnaire survey and thereafter statistical studies are performed to correlate occurrence of airways and lung disease with air pollution. Pulmonary function test was performed following the guideline of American Thoracic Society using portable electronic spirometer. Both, prevalence of respiratory symptoms as well as magnitude of lung function deficit were much higher in the urban study group. Additionally, after controlling potential confounders like gender, smoking habits and socioeconomic status, the higher prevalence of respiratory ailments was found to have significant positive correlation with PM_{10} level in ambient air.

Keywords: air pollution; respiratory symptoms; questionnaire, lung function, pulmonary function

Introduction

Air pollution is recognized as a major threat to human health. Epidemiological studies have shown that concentrations of ambient air particles are associated with a wide range of effects on human health, especially on the cardio-respiratory system (Bates, 1992; Dockery and Pope, 1993). Delhi, the political capital of India is also branded as the air pollution capital of the country. It is one of the ten most polluted cities in the world and the major source for air pollution are vehicular emissions, industrial emissions, household activities and soil resuspension (Balachandran et al., 2000). Among these, vehicular pollution alone contributes to 72% of the total air pollution load in Delhi (Goyal et al., 2006).

Since airborne pollutant generally enters the body through inhalation, lung and the airways are the primary target organs. Various studies have shown association of particulate pollution with wide range of respiratory disorders and hospitalization (Samet, 1981; Pope, 1989, 1991), lung function decrement and respiratory symptoms (Pope and Dockery, 1992; Pope et al., 1991). The respiratory symptoms act as an indicator of underlying disease. These symptoms are usually classified into two broad groups: a) Upper respiratory symptoms (URS) which include runny and stuffy nose, sinusitis, sore throat, wet cough, dry cough, fever, burning or red eyes, and b) Lower respiratory symptoms (LRS) which include wheezing, phlegm, and shortness of breath, chest discomfort or pain.

Along with rise in respiratory symptoms, it is reasonable to assume that the function of lung could be adversely affected following interactions with air toxics, thus resulting in the destruction of the alveoli or the proximal airways. Several studies have shown a decline in forced vital capacity (FVC) and forced expiratory volume (FEV) with increasing concentration of air pollution (Johnson et al., 1982; Lebowitz et al., 1985; Asero et al., 2005). Burnekreef (1997) found a strong association between lung function decrement and particle concentration. Others have also documented decrement in lung function following urban air pollution episode (Frye et al., 2003).

Pulmonary function could be quantitatively measured using a broad array of tests, the most convenient being spirometry. Spirometric maneuvers are used to assess forced vital capacity (FVC), forced expiratory volume in one second (FEV1), maximum mid-expiratory flow (MMEF), and peak expiratory flow rate (PEFR) which indicates functional lung capacity. Pulmonary function can be affected by genetic predisposition, weather, season, and time of the day, the basic respiratory health of the subject, smoking status and air pollution (Schoenberg et al., 1978).

With the above background which suggests positive association of air pollution exposure with deterioration of respiratory health, the present study was undertaken among age and gender matched urban and rural subjects. Questionnaires were used for obtaining information regarding respiratory health (Liard and Neukirch, 2000). In addition, functioning of the lung was quantitatively assessed to unveil the impact of Delhi's air pollution, which is much higher than the recommended standard.

Materials and Methods

Participants:

The study was conducted in different areas of Delhi and West Bengal and Uttaranchal. The sample areas were divided into different homogeneous strata based on air pollution level. Then sampling was done from each stratum randomly. Thus, stratified random sampling procedure was followed under the general plan of Simple Random Sampling without Replacement method. The exposed group consisted of 6005 adults who were residents of Delhi for the past 10 years or more. Among the participants, 4467 (74.4%) were men and 1538 (25.6%) were women. The age of the participants was between 21 and 66 years. The control group included 1046 apparently healthy subjects from the rural areas of West Bengal. Within the control group, 775 (74.1%) were men and 271 (25.9%) were women. The age of the participants varied between 21 and 67 years. Apparently healthy subjects who were residing in Delhi for the last ten years or more without interruptions were included. Individuals under treatment for tuberculosis, cancer, and serious heart, lung or kidney ailments were excluded. Also, pregnant and lactating women were not included as these conditions might modify some of the measured parameters.

Ambient air quality data:

Ambient air quality data with respect to respirable suspended particulate matter (RSPM) or PM_{10}, oxides of nitrogen (NOx) and sulfur (SOx) in study areas were obtained from different air quality monitoring stations of Central and State Pollution Control Board. Additionally, we have measured real-time particulate pollutant concentration in air by portable, battery-operated laser photometer (DustTrak^{TM} Aerosol monitor, model 8520, TSI Inc., MN, USA). The instrument contains 10-mm nylon Dor-Oliver cyclone, operates at a flow rate of 1.7 liter/min and measures particle load in the concentration range of 1µg-100 mg/m^3. The monitor was calibrated to the standard ISO 12103-1 A1 test dust. The monitoring was carried out 8 hours/day for three consecutive days in a week.

Questionnaire survey protocol:

Respiratory health of the subjects was assessed through questionnaire survey. For this, a modified, structured respiratory questionnaire based on the respiratory questionnaire of British Medical Research Council (BMRC, Cotes, 1987), the American Thoracic Society (ATS) and National Heart and Lung Institute (NHLI) Division of Lung Diseases (DLD) questionnaire (ATS-DLD-78-C; Ferris, 1978) was developed.

Prevalence of upper and lower respiratory symptoms in the preceding three months and one year were recorded. Socio-economic status (SES) was ascertained following the procedure of Srivastava (1978) and Tiwari et al., (2005).

Lung function measurements by spirometry:

A total number of 3616 subjects aged between 21 and 67 years participated in spirometric measurements of lung function. Pulmonary function tests (PFT) were performed according to the guidelines of American Thoracic Society (1995) using a portable, electronic spirometer (Spirovit SP-1, Switzerland) with disposable filters (SP-150), designed for ambulatory pulmonary function measurements. Before performing the pulmonary function test, the height and weight of the subject was measured. The device measures actual respiratory flow at a precision of 2% against the predicted values based on age, sex, height, weight and race. Each subject performed at least three forced expiratory maneuvers to allow the choice of the best values. The Forced vital capacity (FVC), Forced expiratory volume at 1 second (FEV_1), Forced expiratory flow at 25-75% ($FEF_{25-75\%}$), maximal mid-expiratory flow rate (MMEF) and Peak expiratory flow rate (PEFR) were measured. Using a computer assisted quantitative assessment the best maneuver for acceptance was determined.

Types of functional lung impairment:

Decrement of lung function detected by spirometry could be generally of two types: obstructive type and restrictive types of impairment. In some cases combined (both obstructive and restrictive) type of lung function impairment could be encountered.

i. Obstructive Type of Lung Function Impairment:
In obstructive type of lung function deficits such as emphysema or chronic bronchitis the FEV1 is reduced disproportionately more than the FVC, resulting in an FEV1/FVC ratio less than 70%. Thus, FEV1/FVC <70% diagnoses airway obstruction. Subjects with obstructive lung had a rapid peak expiratory flow but the curve descends more quickly than normal and takes on a concave shape, reflected by a marked decrease in the FEF25–75%. With more severe obstruction, the peak becomes sharper and the expiratory flow rate drops precipitously.

ii. Restrictive Type of Lung Function Impairment
In restrictive lung type of lung function decrement, the FVC is reduced below 80% of predicted value. The shape of the flow volume loop is relatively unaffected in restrictive disease, but the overall size of the curve appears smaller when compared to normal on the same scale.

iii. Combined Type of Lung Function Impairment
In combined type of lung function impairment, both FVC and FEV1/FVC ratio are appreciably decreased. Subjects having this problem had FVC less than 80%of predicted value and FEV1/FVC ratio<70%.

Statistical analysis:

The collected data were analyzed in EPI info 6.0 and SPSS (Statistical Package for Social Sciences) software. Bivariate correlation for measuring the association between particulate exposure and outcome (e.g. respiratory symptoms, lung function impairment) was done following Spearman's correlation (rho) test. Chi-square test was done for dichotomous or multinomial qualitative variables. The step-up conditional logistic regression was carried out using variables that were significantly associated with the outcome variable for multivariate analysis.

Ethical clearance:

The Institutional Ethics Committee of Chittaranjan National Cancer Institute (CNCI), Kolkata approved the study protocol.

Results

Demographic characteristic

Demographic characteristics of control rural subjects (n=1046) and the residents of Delhi who took part in this study (n=6005) are presented in table 1. Both the groups were comparable with respect to age, gender, BMI, smoking and food habit. But they differed with respect to educational level and fuel use at home.

Table 1.Demographic characteristics of the participants

Characteristics	Control (n=1046)	Delhi (n=6005)	p-value
Median age in year (range)	37(19-67)	35 (19-66)	NS*
Male	74.1	74.4	NS
Female	25.9	25.6	NS
Median BMI in kg/m^2	20.9	23.4	NS
Tobacco smoking/chewing habit (%)			
Current smoker	25.0	23.6	NS
Ex-smoker	0.8	0.7	NS
Never smoker	74.2	75.7	NS
Chewer	6.9	11.3	<0.05
Level of education (% individuals)			
Up to 5 years' of schooling	30.5	32.6	NS
10 years' of schooling	32.6	15.6	<0.05
Graduate	27.5	36.2	<0.05
Postgraduate	5.6	4.1	NS
Professional	3.7	11.5	<0.05
Cooking fuel use at home (%)			NS
LPG	92.8	99.4	<0.05
Kerosene	0.5	0.4	NS
Biomass	6.6	0.2	<0.05

** NS statistically not significant*

Ambient air quality:

The mean annual average respirable suspended particulate matter (RSPM) level in residential areas during the study period in Delhi was 136.8µg/m^3 (Table 2), which was more than double of the standard (60µg/m^3). In contrast, the concentration of PM_{10} in the control areas were significantly lowers (82.5µg/m^3). Concentrations of SO_2 and NO_2 were found to be within standards in Delhi as well as in control areas, but Delhi had a substantially higher level as compared with control (Table 2).

Table 2. Comparison of air quality of the residential areas of Delhi and the control areas

Pollutant ($\mu g/m^3$)	Annual standard for residential areas	Control	Delhi
SPM	140	179.8 ± 24.7	341.8 ± 38.3*
RSPM	60	82.5 ± 14.2	136.8±16.5*
NO_2	60	30.3±5.2	43.4± 5.9*
SO_2	60	5.6± 2.2	9.4± 1.3*

**, p<0.05 compared with control*

Prevalence of respiratory symptoms:

Results showed presence of one or more respiratory symptoms in 33.2% participants of Delhi and 19.6% of control subjects. Thus, the urban individuals had 1.7- times more prevalence of respiratory symptoms compared with rural controls, and the difference between these two groups was highly significant ($p<0.001$). The prevalence of respiratory symptoms was observed to be greater in women compared to men. This is true both in rural and urban settings. Respiratory symptoms in general can be divided into upper and lower respiratory symptoms.

Upper respiratory symptoms (URS):

Sinusitis, rhinitis (runny or stuffy nose), sore throat and common cold with fever were the most prevalent upper respiratory symptoms (URS). In general, 21.5% participants from Delhi in comparison to 14.7% rural controls had one or more of these URS in the past 3 months ($p< 0.05$), Table 3. Compared with control, the relative risk (RR) of URS in Delhi was 1.5 with an odds ratio (OR) =1.59, 95% confidence interval (95%CI) 1.32-1.91.

Smokers are at higher risk as compared the non-smokers. In urban subjects, 23.4% current smokers had URS against 20.9% of non-smokers. Significant relationship existed between URS and SES, with highest prevalence among subjects belonging to low socioeconomic conditions (SES), and least in high SES (OR= 1.49, 95% CI 1.32-1.87).

Among all others, particulate air pollution appeared to be the most significant contributing factor to the genesis of URS. A direct positive correlation between the level of RSPM in breathing air and the prevalence of URS among the residents was found. Considering OR=1 for 50-75 µg/m3 of RSPM, Odds Ratio (OR) of 2.69 with 95% CI 1.91-3.79 was observed for RSPM level above 150 µg/m3

Lower respiratory symptoms (URS):

Recurrent dry cough, cough with phlegm (wet cough), wheeze, breathlessness on exertion and chest discomfort are the major lower respiratory symptoms (LRS) encountered. It was observed that, 22.3% urban individuals (1339 out of 6005) had one or multiple LRS in the past three months in contrast to 12.7% in age and gender matched controls (133 out of 1046) , $p<0.001$ (table 3). The relative risk (RR) of LRS among the residents of Delhi was 1.7, with OR=1.67 (95%CI 1.32-1.93) in univariate logistic regression analysis. As observed in case of URS, smoking and low SES is found to be associated with higher prevalence of LRS.

In multivariate logistic regression analysis, the level of RSPM (PM10) in ambient air was also found to be positively associated with the prevalence of LRS even after controlling potential confounders like smoking, SES, outdoor exposure and season(OR=1.42, 95% CI 1.22-1.63).

Table 3. Prevalence of URS and LRS in past three months

	Upper Respiratory Symptoms (URS)		Lower Respiratory Symptoms (LRS)	
Group	Control (n=1046)	Delhi (n=6005)	Control (n=1046)	Delhi (n=6005)
Male	13.5	20.4*	11.1	21.2
Female	18.1	24.6*	17.3	25.5
Overall	14.7	21.5*	12.7	22.3

Results expressed as percentage of individuals
**, p<0.05 compared with respective control in Chi-square test*

Decreased lung function:

Lung function was reduced in 40.3% residents of Delhi in comparison to 20.1% of control subjects. The difference in the prevalence of lung function deficits between control and Delhi's residents was highly significant ($p<0.001$). The urban individuals had increased prevalence of restrictive (22.5% vs. 11.4% in control), obstructive (10.7% vs. 6.6%), as well as combined type of lung function deficits (7.1% vs. 2.0%). All these results are highly significant (Table 4). Besides higher prevalence, the magnitude of the lung function deficits was much higher in urban individuals as confirmed from the diminished levels of all spirometric measurements. The mean FVC, FEV_1, $FEF_{25-75\%}$ and PEFR values were decreased by 9.4%, 13.3%, 10.4%, and 9.3% respectively among urban subjects (Table 5). All these changes are statistically highly significant ($p<0.05$).

Lung function decrement was more prevalent among female subjects as compared to male, both in Delhi as well as in control group. In urban group, 41.9% women had decreased lung function compared with 39.8% of men ($p<0.05$). Similarly, in control, 24.9% of women had reduced lung function compared with 18.5% of men ($p<0.05$). Interestingly, women had greater prevalence of obstructive and combined type of lung function deficits than men in Delhi, whereas women from control group had greater prevalence of all three types of lung function deficits.

Table 4. Prevalence of lung function deficits

Type of deficit	Control			Exposed		
	Total	Male	Female	Total	Male	Female
Restrictive	11.4	10.8	13.2	22.5*	22.7*	21.9*
Obstructive	6.6	6.2	8.1	10.7*	10.3*	12.1*
Combined	2.0	1.5	3.5	7.1*	6.8*	8.0*
Overall	20.1	18.5	24.9	40.3*	39.8*	41.9*

Results are expressed as percentage of individuals
**, p<0.05 compared with respective control*

Lung function was also found to be decreased more in case of smokers in comparison to non-smokers (49.6% vs. 37.9%). Considering the fact that, smoking can itself induce decrement of lung function, only non-smokers are included for further studies and their magnitude of lung function damage was studied.

Table 5. Comparison of spirometric lung function measurements between non-smoking control subjects and residents of Delhi

Spirometric measurements	Control (n=780)	Delhi (n=2816)	p value
FVC (Lit)	3.38 ± 0.52	3.06 ± 0.43	<0.05
FEV_1(Lit)	2.94 ± 0.54	2.55 ± 0.53	<0.05
$FEF_{25-75\%}$ (Lit/sec)	3.27±0.65	2.93±0.47	<0.05
PEFR (Lit/sec)	3.65±0.83	3.31±0.66	<0.05

Results expressed as Mean± SD

The severity of lung function impairment was subdivided into three categories based on FVC and FEV_1/FVC values: mild (FVC 60-79% and/or FEV_1/FVC 50-69%), moderate (FVC 40-59% and/or FEV_1/FVC 30-49%), and severe (FVC <40% predicted and/or FEV_1/FVC <30%). Overall, 15.1% non-smokers of urban group had mild, 14.6% had moderate and 8.2% had severe decrement in lung function. In contrast, 8.9%, 7.8% and 1.6% of control subjects had mild, moderate and severe type of lung function decrement respectively. $FEF_{25-75\%}$ was declined below 80% of predicted value in 38.6% nonsmokers of Delhi against 21.5% participants from control group, thus suggesting obstruction in the small airways among the former group. Spirometric measurements indicate 1.8-times greater prevalence of small airway obstruction among the non-smokers of Delhi compared with age-matched non-smokers of control group (p<0.001). Decline in PEFR below 80% of predicted value was found in 52.5% participants of Delhi compared to 35.7% of control subjects (p<0.001).

Other than gender, smoking, and age, which causes change in lung function measurement, other possible confounding factors for lung function decrement in nonsmokers could be SES, occupation, and particulate air pollution.

Particulate air pollution and prevalence of lung function deficits:

Of all the potential confounders, particulate air pollution was observed to be most intimately associated with lung function decrement. A strong negative correlation was found between PM_{10} level and the entire lung function measurements. The correlation was strongest for FVC (rho value -0.74, p<0.0005), followed by PEFR (rho value -0.66, p<0.0005), FEV_1 (rho value -0.62, p<0.0005) and FEF25-75% (rho value -0.34, p<0.05).

After controlling potential confounders such as age, gender and SES, logistic regression was done. Analysis confirmed that particulate pollution (PM_{10}) was positively associated with both restrictive (OR= 1.33, 95% CI 1.17-1.58) and obstructive (OR=1.42, 95% CI 1.22-1.89) type of lung function deficits. Conditional regression analysis reaffirmed this finding (table 6).Thus, it appears that Delhi' particulate air pollution is a strong, significant contributor to lung function reductions observed in a large number of residents of the city.

Table 6. Conditional logistic regression analysis of the association between particulate pollution and lung function decrement

PM_{10} (µg/m^3)	OR (95% CI)		
	Restrictive	Obstructive	Overall
50-100	1	1	1
101-150	1.32 (1.11-1.57)	1.45 (1.24-1.84)	1.39 (1.15-1.77)
>150	1.63 (1.31-2.29)	1.83 (1.42-2.67)	1.70 (1.37-2.41)

Discussion

The study has demonstrated a multitude of respiratory health problems among the residents of Delhi who were chronically exposed to high level of air pollution primarily from road traffic. Respiratory symptoms, in general, reflect underlying problems in the airways and the alveoli. Therefore, greater prevalence of respiratory symptoms among the residents of Delhi in comparison to the rural counterparts suggests elevated frequency of airway and alveolar damage. The rural and urban subjects were matched for age and sex; hence physiological variations due to age and sex can be excluded. Since the investigations were carried out simultaneously in Delhi and in control areas, seasonal variation was also negligible. A major difference between the urban and rural settings was the level of air pollution. The residents of Delhi were chronically exposed to significantly elevated levels respirable particulate matter (PM_{10},) in breathing air than their rural counterparts. Hence, the higher level of particulate pollution in city's air appeared to be largely responsible for the health impairments found in urban subjects. There are many reports suggesting possible relationship of exposure to PM and excess mortality and morbidity in humans (Samet, 2002). Morbidity ranges from pulmonary function decrements to respiratory symptoms, and to hospital and emergency department admissions.

In Delhi, the capital city of India, exhaust from motor vehicles is responsible for a substantial part of air pollution. Delhi alone with approximately 1% of India's population, account for about 8% of the national motor vehicles (Badami, 2005). It has been estimated that vehicular source is responsible for generating more than 3000 metric tons of pollutants per day (MT /day) in Delhi and this value is increasing every year. With such a high pollution load, respiratory health of the exposed individuals is expected to be severely affected which has been confirmed from our findings. Compared with rural controls, all the respiratory symptoms were more prevalent in Delhi. Similar to the present finding, air pollution in Bangkok was found to be associated with higher prevalence of respiratory symptoms especially among the traffic policemen, emphasizing the health impact of vehicular pollution (Karita et al., 2001). Other investigations also support this hypothesis (Penard-Morand et al., 2005; Namork et al., 2006).

Besides higher prevalence of respiratory symptoms, higher lung function damage was found, both in men and women of Delhi in comparison to the rural controls.In addition, all the measured lung function parameters, such as FVC, FEV1, FEF25-75%, and PEFR, were decreased by about 10% among the citizens of Delhi. Lung development and attainment of normal lung function in adulthood are influenced by several factors. Most important among these are birth weight, infections, nutrition and environmental factors such as air pollution. It is important to mention in this context that air pollution hampers lung development from childhood to adolescence and adulthood (Khan, 2004). An individual, constantly exposed to high level of air pollution would be highly prone to develop lung function damage. Ackerman-Liebrich et al., 1997 reported effect on lung by chronic exposures to high level of NO2, SO2 and PM, of which the effect is strongest for PM10. Another study has identifiedPM2.5 as the most dangerous particulate fraction (Bernstein and Abelson, 2005). Fine particulates (PM2.5) are ubiquitous because they are largely derived from common combustion processes such as engines of motor vehicles, power generation, burning of biomass, and manufacturing, and they are transported over long distances and readily penetrate indoors are thus important public health concern (Pope 2004). Decline in overall lung function as well as the magnitude of damage has been found to be associated with vehicular pollution by other workers such as Churg et al., 2003. In agreement with this, reductions in FVC and FEV1 have been found in highly polluted areas of Delhi (Chhabra et al., 2001a, b), Kolkata (Lahiri et al., 2000a, b) and Kanpur (Sharma et al., 2004).

Inorganic metals present in dust, when inhaled cause progressive pulmonary fibrosis. Breathlessness, dry cough and general constitutional symptom usually accompany pulmonary fibrosis (Jindal et al., 2001). Inorganic metals (Pb, Cd, Zn, and Ni) are found abundant in particulate pollution of Delhi, especially in fine fraction of PM10 (Balachandran et al., 2000). This could explain the higher prevalence of LRS among the residents of Delhi. Particulate pollution targets respiratory bronchioles, and chronic exposure decreases FEF75 value, implying small airway problems (Hyde et al., 1978). Investigations performed by Churg et al., 2003, on women who were life-long residents of highly polluted Mexico City has shown that particulate matter penetrates and retained in the walls of the airways causing small airway remodeling and chronic air flow obstruction as observed by lung autopsy. The results suggested that PM10 is fibrogenic in individuals exposed to higher levels for longer periods. Other reports have shown that for 34 μg/m3 rise in total suspended particulate matter from the standard, FVC is decreased by 2.25% (Chestnut et al., 1991). Marked decline in morning PEFR has been shown to be associated with exposure to PM10 (Van der Zee et al., 2000).This may explain the higher prevalence of restrictive type of lung function defect among the residents of Delhi. Reduced FVC could be due to fibrosis, edema, hemorrhage, cellular hyperplasia and heavy particle loading. It is known that the respiratory system has a large functional reserve. Therefore, a relatively diffused and extensive lung lesion might have occurred in a substantial number of citizens of Delhi with detectable change in lung function. We did not examine the groups which are assumed to be at higher risk such as individuals with preexisting disease or pregnant and lactating women. Thus we could avoid the chance of interference of these confounding factors in prevalence of lung disease. The question that needs to be addressed is whether the adverse health effects of air pollution are reversible. Studies have shown that adverse effects on lungs are reversible if air quality is improved (Neuberger et al, 2002). Frye et al, 2003 found a significant association for the reduction of TSP and an increase in FVC. Effects of air pollution reduction have also been investigated in animals that were exposed to Boston air and were then moved into filtered air. They showed a continuous reduction in oxidative stress in the lung, which is a biomarker for increased airway and systemic inflammation (Evelson et al, 2000). These reports suggests that relatively small reductions in exposure to PM_{10} have measurable benefits for lung function, suggesting that a decline in air pollution, even from low levels, may have positive consequences for public health.

Conclusions

The report demonstrates a significantly high prevalence of respiratory symptoms and lung function decrement among the citizens of Delhi compared to the rural individuals living in much less polluted areas. Thus, the study proclaims the extent of damage caused by air pollution and with the hope that these changes are reversible if air quality is improved, appeals concerted efforts from policy makers and others concerned for reduction of air pollution in order to protect public health.

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References

Ackermann-Liebrich U, Leuenberger P, Schwartz J, Schindler C, Monn C, Bolognini G, Bongard JP, Brandli O, Domenighetti G, Elsasser S, Grize L, Karrer W, Keller R, Keller-Wossidlo H, Kunzli N, Martin BW, Medici TC, Perruchoud AP, Schoni MH, Tschopp JM, Villiger B, Wuthrich B, Zellweger JP, Zemp E. Lung function and long term exposure to air pollutants in Switzerland. Study on Air Pollution and Lung Diseases in Adults (SAPALDIA) Team. *Am J Respir Crit Care Med,* 155, 122-9, 1997.

Asero V. Mistretta A. Arcidiacono G. Polosa R. Sin DD, Gan WQ, Man SFP. The Puzzling Relationship Between Cigarette Smoking, Reduced Respiratory Function, and Systemic Inflammation, *Chest*, 128, 3772-3773, 2005.

ATS (American Thoracic Society). Standardization of Spirometry. *Am J Respir Crit Care Med*,152, 1107-1136, 1995.

Badami MG. Transport and uban air pollution in India. *Environ Menage*, 36, 195-204, 2005.

Balachandran S, Meena BR, Khillare PS. Particle size distribution and its elemental composition in the ambient air of Delhi. *Environ Int*, 26, 49-54, 2000.

Bates DV. Respiratory Function in Disease. 3rd edn. WB Saunders. Philaladelphia PA. 1989.

Bernstein AS, Abelson HT. PM2.5- A killer in our midst. *Arch Pediatr Adolesc Med,* 159, 786- 786, 2005.

Brunekreef B, Janssen NA, de Hartog J, Harssema H, Knape M, van Vliet P. Air pollution from truck traffic and lung function in children living near motorways. *Epidemiology*, 8, 298- 303, 1997.

Chestnut LG, Schwartz J, Savitz DA, Burchfiel CM. Pulmonary function and ambient particulate matter: epidemiological evidence from NHANES I. *Arch Environ Health*, 46;pp. 135-144, 1991.

Chhabra SK, Chhabra P, Rajpal S, Gupta RK. Ambient air pollution and chronic respiratory morbidity in Delhi. *Arch Environ Health* , 56, 58-64, 2001.

Chhabra SK, Rajpal S, Gupta R. Pattern of smoking in Delhi and comparison of chronic respiratory morbidity among beedi and cigarette smokers. *Indian J Chest Di Allied Sci*, 43, 19- 26, 2001.

Churg A, Brauer M, Avila-Casado MC, Fortoul TI, Wright JL. Chronic Exposure to High Levels of Particulate Air Pollution and Small Airway Remodeling. *Environ Health Perpect*. 111, 714- 718. 2003.

Cotes JE. Medical Research Council Questionnaire on Respiratory Symptoms. *Lancet,* 31, 1028, 1987.

Dockery DW, Arden Pope III C, Xu X, Spengler JD, Ware JH, Fay ME, Ferris (Jr) BG, Speizer FE. An association between air pollution and mortality in six U.S. cities. *N Eng J Med*, 329,1753-1759, 1993.

Evelson P, Gonzalez-Flecha B. Time course and quantitative analysis of the adaptive response to 85% oxygen in the rat lung and heart. Biochim Biophys Acta 2000;1523:209-216.

Ferris BG. Epidemiology Standardization Project (American Thoracic Society). *Am Rev Respir Dis*, 118, 1-120, 1978.

Frye C, Hoelscher B, Cyrys J, Wjst M, Wichmann HE, Heinrich J. Association of lung function with declining ambient air pollution. *Environ Health Perspect,* 111, 383-388, 2003.

Goyal SK, Ghatge SV, Nema P, Tamhane S. Understanding urban vehiclar pollution problem via-a vis ambient air quality- a case study of a megacity (Delhi, India). *Environ Monit Assess*, 2006 (Epub ahead of print).

Hyde D. Morphometric and morphologic evaluation of pulmonary lesions in beagle dogs chronically exposed to high ambient level of air pollutants. *Lab invest*, 38, 455-469, 1978.

Jindal SK, Aggarwal AN, Gupta D. Dut-induced intertitial lung diease in the tropics. *Curr Opin Pulm Med,* 7, 272-277, 2001.

Johnson KG, Loftsgarden DO, Gideon RA. The effects of Mount St. Helens Volcanic Ash on the Pulmonary Function of 120 Elementary School-children. *Am Rev Respir Dis*, 126, 1066- 1069, 1982.

Karita K, Yano E, Jinsart W. Respiratory symptoms and pulmonary function among traffic policemen in Bangkok. *Arch Environ Health*, 56, 467-470, 2001.

Khan A. Air pollution hampers teenagers' lung development. *Thorax,* 59, 1045-1045, 2004.

Lahiri T, Ray MR, Mukherjee S, Basu C, Lahiri P. Marked increase in sputum alveolar macrophages in residents of Calcutta: Possible exposure effect of severe air pollution. *Current Science*, 78, 399-404, 2000a.

Lahiri T, Roy S, Basu C, Ganguly S, Ray MR, Lahiri P. Air pollution in Calcutta elicits adverse pulmonary reaction in children. *Ind J Med Res*, 112, 21-26, 2000b.

Lebowitz MD, Holberg CJ, Boyer B, Hayes C. Respiratory symptoms and peak flow associated with indoor and outdoor air pollutants in the southwest. *J Air Pollut Control Assoc*, 35,1154-1158, 1985.

Liard R, Neukirch F. Questionnaires: a major instrument for respiratory epidemiology. *Eur Respir Mon,* 15, 154-166, 2000.

Namork E, Johansen PV, Lovik M. Detection of allergens adsorbed to ambient air particles collected in four European cities. *Toxicol Lett*, 165, 71-78, 2006.

Neuberger, M, Moshammer H, Kundi M. Declining ambient air pollution and lung function improvement in Austrian children. Atmospheric Environment 36 (2002) 1733–1736.

Penard-Morand C, Charpin D, Raherison C, Kopferschmitt C, Caillaud D, Lavaud F, Annesi- Maesano I. *Clin Exp Allergy,* 35, 1279-1287, 2005.

Pope CA III, Dockery DW. Acute health effects of PM10 pollution on symptomatic and asymptomatic children. *Am Rev Respir Dis*, 145, 1123-1128, 1992.

Pope CA III. Air pollution and health- good news and bad news. (Editorial). *N Eng J Med*, 351, 1132-1134, 2004 b.

Pope CA III. Respiratory disease associated with community air pollution and a steel mill, Utah Valley. *Am J Public Health*, 79, 623-628. 1989.

Pope CA III. Respiratory hospital admissions associated with PM10 pollution in Utah, Salt Lake, and Cache Valleys. *Arch Environ Health*, 46, 90-97,1991.

Samet J. Air pollution and epidemiology: "Déjà vu all over again?" *Epidemiology,* 13, 118-119, 2002.

Samet JM, Speizer FE, Bishop Y. The relationship between air pollution and emergency room visits in an industrial community. *J Air Pollut Control Assoc,* 31, 236-240, 1981.

Schoenberg JB. Beck GJ, Bouhuys A. Growth and decay of pulmonary function. In: Healthy blacks and whites. *Resp Physiol*, 33, 367-393, 1978.

Sharma M, Kumar VN, Katiyar SK, Sharma R, Shukla BP, Sengupta B. Effects of particulate air pollution on the respiratory health of subjects who live in three areas in Kanpur, India. *ArchEnviron Health*, 59, 348-358, 2004.

Srivastava GP. Socio-economic status scale (Urban) Agra: National Psychological Corporation, 1978.

Tiwari SC, Kumar A, Kumar A. Development & standardization of a scale to measure socioeconomic status in urban & rural communities in India. *Indian J Med Res*, 122, 309-314, 2005.

Van der Zee SC, Hoek G, Brunekreef B. Incidence of influenza-like illness, measured by a general practitioner sentinel system, is associated with day-to-day variation in respiratory health in panel studies. *Am J Epidemiol*, 152, 389-392, 2000.

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