Original Article

Effect of Outdoor Air Pollution on Pulmonary Function of Non-smoking Auto-rickshaw Drivers in Bangalore

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Abstract

Background and Aim: Rapid industrialization and urbanization of Bangalore has led to a rise in the levels of ambient air pollution. Studies show that exposure to ambient air pollution is detrimental to health. Auto-rickshaw drivers are highly susceptible to the effects of this pollution. The aim of this study was to assess the magnitude of decrease in lung function of non-smoking auto-rickshaw drivers exposed to outdoor air pollution with relation to normal predicted values. **Methods:** This Cross-sectional study was done in 33 non-smoking auto-rickshaw drivers who were previously asymptomatic and driving for more than 5 years in various parts of Bangalore city in Karnataka. The following parameters of pulmonary function were assessed - FVC (L), FEV1 (L), FEV1 (%), PEFR (L/Second), MVV (L/Min), FEF50 (L/Min), FEF25-75 (L/Min) using the Helios 701 (portable) Spirometer. Statistical analysis was done using IBM statistical package for the social sciences (SPSS) Version 21. **Results:** There was a significant decrease ($P < 0.0001$) in the actual value of FVC, FEV1, PEFR, MVV, FEF50 and FEF25-75 when compared with that of the predicted value. **Conclusion:** Our study shows a significant impairment in the lung function of the auto-drivers with a restrictive type of lung disease.

Keywords: Auto-Rickshaw drivers, spirometer, lung function tests

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Introduction

Outdoor air quality is an important determinant of health of an individual. It is observed that cardiovascular and respiratory system related mortality is more common in highly polluted cities.[1-4]

WHO estimates that outdoor air pollution caused 3.7 million premature deaths worldwide in 2012.[5] These numbers are especially high in developing countries in the Asia-Pacific region, such as India, where urban air pollution causes over 500,000 deaths annually.[6] The burden on developing countries continues to increase every year. Rapid urbanization and industrialization of the Bangalore metropolitan area has contributed to a sharp decline in the city's urban outdoor air quality. Automobile exhausts, heightened by the rising influx of migrants to the city, continue to deteriorate the air quality. Petroleum and diesel fumes, which contain Particulate Matter (PM2.5 and PM10), Nitrogen Dioxide (NO2), Sulfur Dioxide (SO2), Carbon Monoxide (CO), and Ozone (O3) form the major source of these air pollutants.[7] A 2010 study conducted by The Energy and Resources Institute under Central Pollution Control Board revealed that the ambient levels of $PM_{2.5}$, NO_2, CO, and O_3 in Bangalore were in violation of the accepted levels.[8]

Exposure to these fumes has shown to negatively affect the health of the population. Research shows that long term exposure to the automobile exhausts can lead to decrease in lung compliance and function.[5] It has also been attributed to heart and lung diseases, chronic bronchitis, asthma attacks, and other respiratory illness.[5] An increase in benzene levels (a known carcinogen) has also been demonstrated in urban non-smoking traffic policemen and police drivers.[9]

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The detrimental effects of exposure to outdoor air pollution in professional drivers of closed cabin vehicles such as buses and taxis have been observed.[10,11] Drivers of open cabin vehicles are at a higher risk of excessive exposure to these pollutants. A significant proportion of the drivers of open cabin vehicles are auto-rickshaw drivers. They are at an especially high risk for developing health-related issues secondary to outdoor air pollution as the vast majority fail to use any anti-pollution devices for protection and spend more than 6 hours in traffic every day constantly exposed to automobile exhausts. Auto-rickshaw drivers are very susceptible to the effects of outdoor air pollution. There is a need to assess the magnitude of change in the lung function of the auto-rickshaw drivers. Few preliminary studies done earlier in auto-rickshaw drivers have shown lung function abnormalities indicating a restrictive type of lung disease.[12-15] However, these studies were done in various locations (which determine quantum exposure to pollution) with air pollution levels considerably less than Bangalore and the lung parameters tested were insufficient. The aim of this study was to assess the magnitude of change in lung function of non-smoking auto-rickshaw drivers exposed to outdoor air pollution in comparison to normal values correlated to the age, sex, weight and height of the auto-rickshaw drivers.

Materials and Methods

Institutional ethics committee clearance was first obtained. Data collection and analysis was done over a period of 2 months from August to September 2014.

Source and selection of participants

33 non-smoking male auto-rickshaw drivers working for a minimum of 6 hours per day in the Bangalore metropolitan area were selected. Various auto-rickshaw stands in Bangalore were approached for obtaining 33 auto-rickshaw drivers who fulfill the selection criteria. The sample was randomized by selecting auto drivers from various localities of Bangalore city. All the participants had been driving auto-rickshaws in Bangalore for more than 5 years.

A cross-sectional study was performed. Our inclusion criteria included male auto-rickshaw drivers aged: 18 to 60 years, non-smoking and no history of usage of protective anti-pollution gear i.e. faces masks. Auto-rickshaw drivers with night-time only shift, working hours: less than 6 hours per day, history of smoking (beedi and/or cigarette), history of any thoracic surgery, current respiratory infections, structural abnormalities of the thorax and vertebral column i.e. Kyphosis and Scoliosis, history suggestive of cardiovascular disease i.e. ischemic heart disease, myocardial infarction, and with any known cardiorespiratory system malady or malignancy were exclude from the study. The subjects were informed that their participation is entirely voluntary. The procedure and purpose of the experiment was explained to them; they were notified that it is an anonymous study and written consent was taken.

Questions were asked and answers recorded regarding education and socioeconomic status, work experience such as years of driving experience in Bangalore, shift timings, locality of work to assess traffic density, and use of protective equipment like face masks. Symptoms of any respiratory disease in the past twelve months, any confirmed diagnosis of respiratory disease and any medications taken, history of any systemic disease such as ischemic heart disease, family history of any respiratory disease, surgical history, and personal habits such as smoking were also asked. The age, sex of the subject was recorded. Weight and height of the subject was recorded without shoes and BMI calculated. Then, a thorough general physical examination and a systemic respiratory system examination were performed. The heart rate, blood pressure (right arm) and respiratory rate were recorded in the sitting position.

The following parameters of pulmonary function were assessed – Forced Vital Capacity (FVC) in Liters (L), Forced Expiratory Volume in the first second (FEV1) in Liters (L), Forced Expiratory Volume in first second by Forced Vital Capacity (FEV1/FVC) in Percentage(%), Peak Expiratory Flow Rate (PEFR) in Liters/second (L/second), Maximum Ventilatory Volume (MVV) in Liters/minute (L/Min), Forced Expiratory Flow - 50% (FEF50) in Liters/minute (L/Min), Forced Expiratory Flow – 25-75% (FEF25-75) in Liters/minute (L/Min) using the Helios 701 (portable) Spirometer manufactured by Recorders and Medicare Systems Pvt. Ltd. The participants were instructed to perform specific maneuvers with the handheld spirometer device following standardized procedure.[16] All the recordings were taken in standing position. Each maneuver was repeated at least three times and the best attempt was selected and recorded. Properly fitting disposable mouthpieces were used for each participant.

Statistical analysis

All statistical analysis was performed using IBM SPSS 21 Software. Descriptive data of the actual and predicted values for FVC (L), FEV1 (L), FEV1 (%), PEFR (L/Second), MVV (L/Min), FEF50 (L/Min), FEF25-75 (L/Min) with the percentage difference was represented through mean and standard deviation. Inferential analysis (significance testing) of actual and predicted values for FVC (L), FEV1 (L), FEV1 (%), PEFR (L/Second), MVV (L/Min), FEF50 (L/Min), FEF25-75 (L/Min) was assessed with *P* less than 0.01 being significant and *P* less than 0.001 being highly significant.

Results

The demographic profiles of the 33 non-smoking auto-rickshaw drivers are listed in Table 1. All the 33 participants worked more than 6 hours per day for the day shift. No abnormalities were revealed on respiratory system examination of the participants although 19 of the 33 participants were undiagnosed hypertensives [Table 1]. Table 2 shows the lung function parameters and Table 3 shows the mean percentage

change between the actual and predicted value of lung function parameters in non-smoking auto-rickshaw drivers.

There was a significant decrease in the actual value of FVC ($P < 0.001$) when compared with that of the predicted value. The percentage change in FVC was 23.76%

The actual FEV1 was 13.23% less than the predicted value and was statistically significant ($P < 0.001$). However, the ratio of FEV1/FVC% remained normal. There was a significant decrease in the actual value of PEFR, MVV, FEF50 ($P < 0.001$)

Table 1: The demographic profiles of the 33 nonsmoking auto-rickshaw drivers

Parameter	Mean±SD
Age (years)	43.33±9.313
Weight (kg)	74.21±11.252
Height (cm)	166.18±7.372
Body mass index	26.918±3.9748
Heart rate (beats/min)	74.73±9.169
Systolic blood pressure (mmHg)	138.97±19.894
Diastolic blood pressure (mmHg)	93.27±11.681
Respiratory rate (cycles/min)	16.30±1.591

Values are expressed as mean±SD. SD: Standard deviation

Table 2: Lung function parameters of the given subjects

Parameter	Actual value ($n=33$)	Predicted value ($n=33$)	*P*
FVC (L)	2.43±0.51	3.22±0.41	<0.000
FEV1 (L)	2.25±0.52	2.61±0.38	<0.000
FEV1/FVC (%)	91.27±8.99	-	-
PEFR (L/s)	5.15±1.60	8.47±0.67	<0.000
MVV (L/min)	76.55±20.22	125.94±12.77	<0.000
FEF50 (L)	3.67±1.00	5.44±0.42	<0.000
FEF25-75 (L)	3.23±0.88	3.72±0.48	0.003

Values are expressed as mean±SD. Analysis done by Student's unpaired *t*-test. $P<0.01$ considered statistically significant. $P<0.001$ considered statistically highly significant. FVC: Forced vital capacity, FEV1: Forced expiratory volume in the 1st s, PEFR: Peak expiratory flow rate, MVV: Maximum ventilatory volume, FEF50: Forced expiratory flow at 50%, FEF25-75: Forced expiratory flow at 25%-75%, SD: Standard deviation

Table 3: Percentage change between the actual and predicted value of lung function parameters

Parameter	Percentage change (%)
FVC (L)	23.76±13.20
FEV1 (L)	13.23±20.71
PEFR (L/s)	38.48±20.35
MVV (L/min)	39.27±15.90
FEF50 (L)	32.55±19.47
FEF25-75 (L)	12.67±24.07

Values are expressed as mean±SD. FVC: Forced vital capacity, FEV1: Forced expiratory volume in the 1st s, PEFR: Peak expiratory flow rate, MVV: Maximum ventilatory volume, FEF50: Forced expiratory flow at 50%, FEF25-75: Forced expiratory flow at 25%-75%, SD: Standard deviation

when compared with that of the predicted value. There was a significant reduction ($P < 0.001$) in the actual value of FEF25-75 and the percentage change in FEF25-75 was 12.67% less than the predicted value [Tables 2 and 3].

Discussion

Studies show that exposure to ambient air pollution is detrimental to health. Auto-rickshaw drivers are highly susceptible to the effects of this pollution. They are constantly exposed to outdoor air pollution and our study shows that their lung function is deteriorating. There is a decrease in all parameters of lung function except FEV1/FVC%. The Forced Vital Capacity (FVC) was reduced by more than 20% compared to the adjusted predicted values. The decrement in Forced Expiratory Volume in the First Second (FEV1) was also substantial. Both were statistically highly significant. The FEV1/FVC% remained normal. The Peak Expiratory Flow Rate (PEFR), Maximum Ventilatory Volume (MVV) and Forced Expiratory Flow at 50% (FEV50%) showed a greater than 30% decline with relation to the adjusted predicted values. The Forced Expiratory Flow-25% to 75% (FEF25%-75%) showed only a 12% decrease from the predicted values but remained statistically significant.

In Gulbarga(17), FVC, FEV1, FEV1/FVC%, PEFR, MVV, FEF50 and FEF25-75 in 50 non-smoking auto-rickshaw drivers were compared against 50 controls and they concluded that the FVC, FEV1, FEF50 and FEF25-75 were significantly decreased. FEV1/FVC% was 88%. However, in their study there was no significant decrement in PEFR and MVV. Bangalore being a more polluted city could explain the significant reduction in PEFR and MVV observed in our study.

In Pune[12] they compared FVC, FEV1, FEV1/FVC% and PEFR in 100 non-smoking auto rickshaw drivers with matched controls. The reduction in parameters FVC, FEV1 and PEFR were statistically significant. The mean PEFR value in their study was 8.18L/second. This was much higher compared to our study, where it stood at 5.1L. No significant decrement was seen in FEV1/FVC% which was 90%.

There are two recognized patterns of lung disease: obstructive and restrictive. The former is characterized by significant decrease in FVC with decrease in FEV1/FVC% less than 85%. The latter is characterized by significant decrease in FVC with no decrease in FEV1/FVC% (it remains above 85%). Our study suggests a restrictive pattern of lung disease as the FEV1/FVC (%) was normal (91%) but FVC was significantly decreased. This was also observed in studies done in Pune[12] and Gulbarga.[17] In addition, PEFR and MVV were also affected in our study.

The exact mechanism of deterioration in lung function is unclear but it may be explained by the dangerously high levels of PM2.5, NO2, CO, and O3 in Bangalore.[8] Particulate matter (PM) in outdoor air pollution is associated with significant decrease in lung function[18] and the nitrogen oxides (NO_2) in air causes terminal alveolar damage resulting

in decreased pulmonary compliance and capacity.[19] Exposure to ozone has led to reduction in lung functions.[20] Long-term exposure of rat lungs to ozone (O_3) caused restrictive type of lung disease by causing lung stiffening;[21] O_3 can also produce pulmonary fibrosis.[22] These effects, in combination with the respiratory muscle weakening action of carbon monoxide,[23] can explain the significant decrease in the lung function test parameters and the primarily restrictive pattern of lung disease observed in our study.

Limitations of the study

A small sample size was employed due to limited manpower. As our study included only auto-rickshaw drivers driving for more than 5 years, we weren't able to assess the effects on drivers who had been driving for less than 5 years. As we including only non-smoking auto-rickshaw drivers, we were not able to assess as the effects of air pollution on the lung function of smoking auto-rickshaw drivers, who form the majority of auto-rickshaw drivers in Bangalore. Further studies using a larger sample with a cohort study model incorporating analysis of the effect of preventive measures against air pollution on lung function is required.

Conclusion

Auto-rickshaw drivers depend on driving as their livelihood. Outdoor air pollution is a significant occupational hazard. Our study confirms that exposure to outdoor air pollution is detrimental to the health of the auto-rickshaw drivers and points to a restrictive type of lung disease. Preventive measures need to be taken along the lines of legislative and social measures to reduce the levels of outdoor air pollution; use of personal anti-pollution protective equipment, awareness drives and health education about the detrimental effects of air pollution on lung function and health. Further studies using a larger sample with a cohort study model with analysis of the effect of preventive measures against air pollution on lung function is required.

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Conflicts of interest

There are no conflicts of interest.

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