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Effects of Exposure to Automobile Exhausts on Pulmonary Function Tests in Traffic Policemen of Goa

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ABSTRACT

Health problems posed by air pollutants at the work environment of an individual are closely linked to the nature and level of exposure to these hazardous chemicals. Development of adverse effects due to these substances depends on the chemical, physical and biological nature of the substance, the concentration of the substance in air, the intensity and duration of exposure and lastly, the host susceptibility.

Spirometry is commonly used in clinical medicine and research to evaluate effects of exposure on the respiratory system. It is the preferred tool to establish baseline lung function, to evaluate dyspnoea, detect pulmonary disease, monitor effect of therapy used to treat respiratory disease, to evaluate operative risk, control occupational lung diseases and in sports medicine.

Spirometric measures of lung function, namely maximum forced vital capacity (FVC) and maximum forced expiratory volume in one second (FEV1) are early indicators of chronic respiratory and systemic inflammation, as well as premature cardio-respiratory mortality.

Traffic policemen are among the subjects maximally exposed to traffic-related pollution. Spirometric analysis done in traffic policemen showed significant variations in peak expiratory flow rate, forced expiratory volume in one second and forced vital capacity. It revealed significant respiratory impairment in the traffic policemen due to exposure to vehicular pollution.

It was also observed that the values of other pulmonary function parameters were decreased in occupationally exposed traffic policemen group in comparison to that of the non-traffic policemen of the control group. On analyzing and comparing the data collected, it was concluded that the prevalence of lung disorders, both obstructive and restrictive, in occupationally exposed traffic policemen group was higher than that of the non-traffic policemen of the control group. Traffic policemen are highly vulnerable to respiratory impairment due to vehicular exhaust at workplace environment and that the appraisal of the health condition, of the affected traffic policemen group, could be alleviated by preventive measures such as the use of masks and periodic health check-ups. Awareness programmes on health impacts of pollution need to be adopted for the protection of traffic policemen working along heavily polluted roads.

Key Words: Pulmonary function test; Automobile exhaust; Traffic police

INTRODUCTION

Air pollution is one of the serious problems faced by people in developing countries like India.[1] Like many other parts of the world, air pollution from motor vehicles is one of the most serious and rapidly growing problems in urban centres of India.

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The problem has further been compounded by the concentration of large number of vehicles and comparatively high motor vehicles to population ratios in these cities.[2]

Working conditions and the nature of employment tend to have major repercussions on the health of a workman. Automobile exhaust is the major air contaminant in the advanced and the rapidly developing countries of the world. The major causes of increased emissions of pollutants in urban areas include the use of poor quality fuel, traffic congestion and bad maintenance of motor vehicles.[1] The air pollutants discharged in automobile emissions include polycyclic hydrocarbons, compounds of lead, oxides of nitrogen, carbon monoxide, ozone, etc. These pollutants are mostly the result of incomplete combustion of hydrocarbons and the use of leaded petrol in vehicles.

Airborne dust plays a major part in the overall atmospheric pollution and the motor vehicle emissions constitute the most significant source of ultrafine particles in an urban environment. The smoke emitted by these vehicles is a mixture of particles and gaseous chemicals of varying physical and chemical properties. When inhaled, these cause damage to the airways and the lungs. The particles increase the toxicity of the chemicals present in the smoke.[3] Recent evidence suggests that diesel engine emissions are more dangerous than previously considered. Diesel exhaust, a major source of fine particulates in urban areas, is carcinogenic. In addition, fine particles in diesel exhaust may enhance allergic and inflammatory responses to antigen challenge, which may facilitate development of new allergies. Thus, diesel exhaust exposure may worsen symptoms in those with allergic rhinitis or asthma linked to short-term or long-term exposures.[4]

In combination with particulate pollutants, sulphur dioxide and nitrous oxide have greater chance to reach the deeper parts of the lung. The gaseous pollutants may also alter the properties and concentration of surfactant and may thus contribute to the early closure of small airways.[5]

The effects of air pollution include breathing and respiratory problems, aggravation of existing respiratory and cardiovascular disease, alterations in the body defense systems against foreign materials, damage to lung tissue, carcinogenesis and premature death.[6]

Various studies have been conducted on the effects of automobile exhaust on the respiratory and health status of traffic police. Speizer FE et al studied the prevalence of chronic non-specific respiratory diseases in a population of 268 New England policemen exposed to a spectrum of levels of automobile exhaust as traffic officers. Two-third of these diagnoses were simple chronic bronchitis alone.[7] Thippana G et al conducted a study in 665 male traffic police constables mainly in the city where traffic congestion was very high. 0.9% of the constables were found to be having severe restrictive ventilator defect. Singh V et al screened traffic police constables in the more traffic congested areas of Jaipur city. A large number of the police (84 out of 100) suffered from various degrees of respiratory problems like cough, difficulty in breathing, blocked noses, breathlessness following a little strain, formation of black sputum, etc. Some complained of frequent asthmatic attacks and mild pains in the chest. They showed greater vulnerability to lung diseases.[8] Kumar NVN et al carried out an occupational study on respiratory disorders of 80 traffic policemen in Tirupati (AP), India. Their health status was recorded for various occupational respiratory diseases. Their exposure time was also recorded. There was a significant statistical correlation between period of exposure and increase in admission rate for respiratory disorders.

Traffic police personnel who were occupationally exposed for larger period in their life have been reported to have more number of admissions than traffic police with less exposure period.[9] Pal P et al conducted a study on pulmonary function test (PFT) parameters of traffic police personnel of Pondicherry, to assess the effect of traffic air pollution on their pulmonary functions. PFT parameters were recorded in 30 traffic police personnel (study group) and 30 general police personnel (control group) of male gender. In non-smokers, there was significant decrease in vital capacity (VC), forced expiratory volume in 1 second (FEV1), forced expiratory flow at 25% of volume as a percentage of VC (FEF25) and peak inspiratory flow (PIF) in study group when compared to the control group. These changes indicate restriction to the lung expansion, and obstruction and narrowing of the airways in traffic police personnel as compared to the general police personnel.[10]

Most of the studies conducted on traffic police[9,11–13] have concluded that the respiratory health in the exposed subjects was on a decline.

Considering the heavy traffic flow in the heart of Goan cities, we planned a first ever study in the state of Goa to ascertain the effect of vehicular pollution on the respiratory parameters of Goan policemen.

MATERIALS AND METHODS

This study was conducted on 260 policemen in the age group of 20–60 years. The study comprised 130 traffic policemen working on roads with intense flow of traffic, along with 130 healthy non-traffic policemen who carried out indoor activities of administrative and bureaucratic nature.

For comparative study purpose, the policemen were divided into study group (traffic policemen) and control group (non-traffic policemen). Both the groups were further divided into four categories each based on the age (20–29, 30–39, 40–49, 50–59), and were paired with equal number in the study and control groups.

A questionnaire was prepared in order to conduct a primary screening of traffic policemen to exclude gross pulmonary and cardiac diseases not caused due to occupational hazards, including congenital heart disease, pulmonary tuberculosis, central and peripheral nervous system disorders or any other disorders, which may hamper the final results. Clinical examination was conducted on all traffic policemen and relevant findings were noted in the proforma. In addition, anthropometrical measurements such as age (in years), height (in cms), weight (in kgs), body surface area (in metre square), body mass index (in metre square) and chest expansion (in cms) were noted. The Spirovit 1 instrument was used to record the various parameters of lung function.

Three different tests namely, forced vital capacity (FVC), slow vital capacity (SVC) and maximum voluntary ventilation (MVV) were conducted on each subject. The following parameters were recorded by the computerized spirometer: Vital capacity (VC), forced expiratory volume in 1 second (FEV1), peak expiratory flow (PEF), maximum voluntary ventilation (MVV), forced expiratory flow at 25–75% of volume as a percentage of VC (FEF25–75%) and FEV1 as a percentage of VC (FEV1/VC).

RESULTS

The findings of the various parameters considered in the PFT were recorded and tabulated. The values of age, height and weight were not significant among the study group and controls. These data were represented as mean value with standard deviation, and error of mean was calculated for testing the prevalence of differences in respiratory functions among the study and control groups. A comparison of spirometric measurements was performed by Student's t-test.

The mean values of SVC, FVC, FEV1, FEV1/SVC, MVV, FEF25–75% and PEF are shown in the **Tables 1** to **7**, respectively.

Table 1 Comparison of mean value of SVC between control and traffic policemen in age groups 20–29, 30–39, 40–49, 50–59 years

Slow Vital Capacity (SVC)				
Group	*Age in Years*			
	20–29	30–39	40–49	50–59
Control (n=130)				
Mean (L)	5.067	4.515	4.027	4.022
SE±	0.192	0.109	0.140	0.092
Traffic (n=130)				
Mean (L)	3.476	3.729	3.362	3.211
SE±	0.228	0.108	0.126	0.136
p value	0.000^{***}	0.000^{***}	0.001^{***}	0.000^{***}

$^{***}p<0.001$

Table 2 Comparison of mean value of FVC between control and traffic policemen in age groups 20–29, 30–39, 40–49, 50–59 years

Forced Vital Capacity (FVC)				
Group	*Age in Years*			
	20–29	30–39	40–49	50–59
Control (n=130)				
Mean (L)	4.999	4.449	4.131	3.861
SE±	0.161	0.113	0.138	0.143
Traffic (n=130)				
Mean (L)	3.788	3.866	3.567	3.210
SE±	0.137	0.086	0.121	0.117
p value	0.000^{***}	0.000^{***}	0.003^{**}	0.001^{***}

$^{**}p<0.01$, $^{***}p<0.001$

DISCUSSION

Air quality is deteriorating especially in cities, mainly due to vehicular emissions. There is good evidence that the health of 900 million urban people over the world is worsening daily because of high levels of ambient air pollutants.[14] The toxicology of air pollution is exceedingly complex as there are different types of pollutants affecting individuals differently.[15] It was reported that pollution from automobile exhausts was about 70% of the total ambient air pollution among large cities.[13] Exhaust emissions from vehicles is a well known problem with studies showing increasing adverse health effects with rising levels.[16–19] The most widely reported pollutants in vehicular exhaust include carbon monoxide, nitrogen and sulphur oxides, unburnt hydrocarbons (from fuel and crankcase oil), particulate matter, polycyclic aromatic hydrocarbons and other organic compounds that derive from combustion.[20] Motor vehicular emissions constitute the most significant source of ultrafine particles in an urban environment.[18] The smoke emitted by these vehicles is a mixture of particles and gaseous chemicals of varying physical and chemical properties. When inhaled, these cause damage to the airways and the lungs.[21] Asthma exacerbations, increased respiratory symptoms and illness, decreased lung function, lung inflammation, increased airway reactivity and altered host response occurred in response to increase in air pollutants.[22]

Table 3 Comparison of mean value of FEV1 between control and traffic policemen in age groups 20–29, 30–39, 40–49, 50–59 years

Forced Expiratory Volume in 1 Second (FEV1)				
Group	***Age in Years***			
	20–20	30–39	40–49	50–59
Control (n=130)				
Mean (L)	4.714	4.157	3.745	3.520
SE±	0.143	0.113	0.125	O.118
Traffic (n=130)				
Mean (L)	3.618	3.616	3.224	2.884
SE±	0.128	0.781	0.110	0.112
p value	0.000***	0.000***	0.003**	0.000***

**$p<0.01$, ***$p<0.001$

The potential association between long-term exposure to air pollution and histopathological evidence of damage to human lungs was evaluated by Souza et al, and the results of his study suggested that long-term exposure to air pollutants may contribute to the pathogenesis of airway disease.[23] Policemen, taxi drivers, postmen and traffic wardens were considered the most highly exposed occupational groups in cities.[13]

Lung function has been one of the most important assessment tools available to investigators of the health effects of air pollution. Although some measurements of lung function require sophisticated equipment, basic lung function parameters can be measured with spirometers.[24] Various parameters like SVC, FVC, FEV1, MVV, FEFR25–75% and PEFR were considered in the present study in order to evaluate the respiratory status of traffic policemen in the state of Goa compared to their control groups. The spirometric analysis performed on these traffic policemen showed significant variations in the parameters mentioned above.

Table 4 Comparison of mean value of FEV1/SVC between control and traffic policemen in age groups 20–29, 30–39, 40–49, 50–59 years

Forced Expiratory Volume in 1 Sec per Slow Vital Capacity (FEV1/SVC)				
Group	***Age in Years***			
	20–29	30–39	40–49	50–59
Control (n=130)				
Mean (%)	95.903	93.074	94.366	88.305
SE±	2.619	1.878	2.603	2.090
Traffic (n=130)				
Mean (%)	107.953	97.674	97.117	91.433
SE±	3.840	2.086	2.995	3.206
p value	0.012*	0.106	0.490	0.429

*$p<0.05$

Table 5 Comparison of mean value of MVV between control and traffic policemen in age groups 20–29, 30–39, 40–49, 50–59 years

Maximum Voluntary Ventilation (MVV)				
Group	***Age in Years***			
	20–29	30–39	40–49	50–59
Control (n=130)				
Mean (L/min)	165.043	154.270	145.480	147.000
SE±	6.548	5.998	4.879	5.603
Traffic (n=130)				
Mean (L/min)	138.923	141.245	128.260	104.243
SE±	6.912	4.751	5.607	5.451
p value	0.008**	0.092	0.024*	0.000***

*p<0.05, **p<0.01, ***p<0.001

These parameters were significantly lowered in the traffic policemen group compared to the control groups, thus revealing significant respiratory impairment in the traffic policemen group, which could be due to exposure to vehicular pollution. VC is the maximum amount of air taken in or out of the lungs per breath.[13] The FVC is a maximally rapid expiratory vital capacity. In the present study, there was a decrease in FVC and SVC in traffic policemen group compared to their predicted values. There was also a decrease in these parameters in comparison to their controls in all the age groups taken in this study. This suggests that there was a decrease in maximal expiratory flow rate, so that rapid emptying of the lungs was not possible, thus indicating an obstructive ventilatory defect, which could be due to the effect of particulate matter, ozone, sulphur dioxide and diesel exhaust on the airways, which causes increase in airway responsiveness and resistance thereby altering lung volume and flow. Findings of similar studies conducted by Ingle ST et al,[6] Speizer FE et al,[7] Ogunsola OJ et al,[11] Wongsurakiat et al,[25] Kim SM et al,[26] De Toni A et al[27] and Zhang YX et al[28] match with our study.

Table 6 Comparison of mean value of FEF 25–75% between control and traffic policemen in age groups 20–29, 30–39, 40–49, 50–59 years

Forced Expiratory Flow Rate at 25–75% (FEF 25–75%)				
Group	***Age in Years***			
	20–29	30–39	40–49	50–59
Control (n=130)				
Mean (L/sec)	6.457	6.030	5.347	5.179
SE±	0.225	0.217	0.131	0.229
Traffic (n=130)				
Mean (L/sec)	5.640	5.385	4.296	3.911
SE±	0.265	0.202	0.188	0.269
p value	0.022*	0.033*	0.000***	0.001***

*p<0.05, ***p<0.001

Table 7 Comparison of mean value of PEF between control and traffic policemen in age groups 20–29, 30–39, 40–49, 50–59 years

Peak Expiratory Flow Rate (PEF)				
Group	***Age in Years***			
	20–29	30–39	40–49	50–59
Control (n=130)				
Mean (L/sec)	9.973	9.314	8.448	8.327
SE±	0.327	0.344	0.276	0.360
Traffic (n=130)				
Mean (L/sec)	8.086	8.280	7.634	6.224
SE±	0.388	0.234	0.291	0.327
p value	0.000***	0.015*	0.046*	0.000***

*p<0.05, ***p<0.001

MVV is the maximum amount of air breathed in or out of the lungs per minute.[29] Although it is non-specific and occurs in obstructive, restrictive, neuromuscular and heart diseases, it is an indicator of functional capacity of the lungs.[30] In our study, it was observed that there was a decrease in MVV values in the traffic policemen group compared to their controls who were not exposed to air pollution. Therefore, this shows that some degree of restriction is present in them that are limiting their lungs to expand. These changes might be in the lung tissues due to chronic irritation by pollutants of automobile exhausts. Similar findings were reported by Sattapathy DM et al,[5] Thippana G et al,[8] Kumar NVN et al,[9] Pal P et al,[10] Singh V et al[31] and Cerebellia R et al.[32]

FEV1 is the most reproducible, most commonly obtained, and possibly the most useful measurement. It is the volume of air exhaled in the first second of the FVC test. It is decreased in obstructive and restrictive lung diseases. In our study, there was a reduction in FEV1 in the traffic policemen group compared to their predicted values as well as their controls.

The FEV1/FVC ratio is generally expressed as a percentage. The amount exhaled during the first second is a fairly constant fraction of the FVC, irrespective of lung size. The significance of this ratio is to quickly identify persons with airway obstruction in whom FVC is reduced and this ratio is valuable for identifying the cause of low FEV1.[30]

In order to determine whether a reduced FEV1 is due to airway obstruction or a restrictive process is to check FEV1/FVC ratio. A low FEV1 with normal ratio usually indicates a restrictive process, whereas a low FEV1 and a decreased ratio signifies a predominantly obstructive process.[30] In our study, we found a low FEV1 with normal FEV1/FVC ratio, thus indicating some degree of restriction seen in the traffic policemen attributed to the effect of exposure of their airways to air pollutants. The findings of our study were similar to the studies done by Ingle ST et al,[6] Speizer FE et al,[7] Thippana G et al,[8] Ogunsola OJ et al,[11] Wongsurakiat P et al,[25] Kim SM et al,[26] De Toni A et al[27] and Zhang YX et al.[28]

PEFR is the maximum rate of flow during expiration.[29] Both FEV1 and PEFR are indicators of the capacity of the expiratory muscles. In the present study, FEV1 and PEFR were less in traffic policemen group compared to their predicated values as well as their controls, thus indicating there was some obstruction during expiration, which can be attributed to the inflammatory effects brought about by particulate matter because of its small size and chemical composition, which damage the airways by generating free radicals and stress. Thus, this significant reduction in PEF indicates the warning symptoms of asthma among traffic policemen. These findings were similar to those of Pal P et al,[10] Ingle ST et al,[6] Speizer FE et al[7] and Ogunsola OJ et al.[11]

FEF25–75% is the rate of air flow between 25% and 75% of FVC. It is a sensitive measurement. It indicates the conditions of larger and smaller airways.[33] It is reduced in traffic policemen group in comparison to their predicted value as well as their controls. This reduced value indicates early obstruction involving the smaller airways, which are the primary sites of deposition of inhaled pollutants. This suggests that the airways in general are narrow, preventing the free flow of air during respiration. All these findings are similar to studies done by Ogunsola OJ et al,[11] Karita K et al,[12] Zhang YX et al[27] and Pal P et al.[30]

When all the above parameters were analysed together, it was noticed that they were all reduced in the traffic policemen group except FEV1/FVC ratio, which was normal. These findings mainly indicated restricted lung impairment.

The reduced value of PEFR indicates obstructive lung impairment in traffic policemen. Significant reduction of FEV1, FVC and FEF25–75% indicated mixed restrictive and obstructive impairments, which probably could be attributed to the adverse effects of small particulate matter (SPM), carbon monoxide (CO), carbon dioxide (CO_2), nitrogen dioxide (NO_2), ozone (O_3) and sulphur dioxide (SO_2) contents of diesel taxi effluents on respiratory system.

According to the study conducted by Dockery et al, exposure to automobile exhaust and fuel vapour impairs lung function in a time dependent manner.[34] However, the present study did not take into consideration the duration of exposure of the traffic policemen to air pollutants as their work shifts involved areas of differing levels of air pollution of automobile exhaust.

This study reveals that traffic policemen are highly vulnerable to respiratory impairment due to vehicular exhaust at workplace environment, and that the appraisal of the health condition of the affected traffic policemen group could be alleviated by preventive measures, such as the use of mask, periodic health check-ups and awareness on health impacts of pollution. These are especially needed to be adopted for the protection of traffic policemen working along heavily polluted roads.

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