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ORIGINAL ARTICLE **OPEN ACCESS**

Impact of worsening air quality on pulmonary function and health of personnel predominantly involved in indoor tasks- An observational study in DMRC staff

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ABSTRACT

As per World Health Organization findings, Delhi is among the most polluted city and particulate matter are the prime cause. Vehicular emissions, industrial activities and combustion of agro bi products were detected equally in indoor & outdoor settings. CISF metro staff are professionals primarily involved in laborious field work and they require periodic health assessment. To assess respiratory health of CISF security personnel (DMRC) posted at different areas of Delhi (who are working in indoor environmental conditions). 391 subjects participated in the study from Delhi (different regions) according to inclusion and exclusion criterion by convenience sampling after getting permission from CISF DMRC Head for the conduction of the study and Ethical approval was sought prior to the study. Pulmonary functions (FVC, PEFR, FEV_1,FEV_1/FVC and FEF $_{25-75\%}$) were investigated by PFT instrument(RMS, Helios-401). Study was conducted in February 2019, after receiving informed consent from all subjects. Other instrumentation used were weighing scale, stadiometer and Disposable mouth pieces for each individual. The study conducted among CISF DMRC staff (mean age 24.85 years) revealed a decline in the PFT parameters (forced vital capacity, peak expiratory flow rate, forced expiratory volume in 1 second, ratio of forced expiratory flow in 1 second to forced vital capacity and forced expiratory flow 25-75%) compared to predictive values. Among the total population screened, 35.54% showed obstruction, 8.43% exhibited restriction, 1.53% showed mixed blockage and 59.33% had early small airways obstruction in lungs. West Delhi showed the highest ratio of normal individuals in comparison to north (OR-3.25), south (OR- 1.72) and east (OR- 2.62) Delhi. It was concluded that to a certain extent, even the individuals working in the indoor occupational workspace and those not directly exposed suffer from deterioration in pulmonary health and lung capacities due to alarming rising air pollution levels.

Key words: Air pollution, Spirometry, CISF DMRC security personnel

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INTRODUCTION

The respiratory system suffers negative consequences as a result of air pollution. Vehicle emissions are the primary cause of the air quality issue in cities, making road traffic-related air pollution a potential health risk for everyone in the world[1, 2]. According to a WHO report, Delhi is the most polluted city in the world, and smoke from the city's industries is the main source of particulate matter, or solid and liquid particles with a diameter of less than 2.5 micrometers[3].

The World Health Organization's Urban Air Database report released in September 2011 states that Delhi exceeded the PM10 limit by nearly 10 times, reaching 198 micrograms per cubic meter, tied for third rank with the Indian metropolis. Vehicle-related air pollution exposure has been found to increase mortality and morbidity from respiratory and cardiovascular disease in humans [4], while lung function decline is reversed [4][5].

Urban workers, such as traffic police officers, street sweepers, postal workers, and newspaper vendors, are exposed to a substantial amount of traffic fumes, posing a health risk related to outdoor environment exposure to dust and air pollutants without any preventive measure, making them susceptible to weakened lung function over the course of time [6][4]. Those who work long shifts on the roads as part of their jobs will undoubtedly be exposed to these toxins to a significant extent. Prolonged exposure to

diesel exhaust particles from moving cars causes coughing, phlegm production, and deteriorating lung function [7][2].

The increased incidence of numerous cytological alterations in sputum in Delhi was associated with an increase in the metaplasia and dysplasia of airway epithelial cells[8]. Major health effects of exposure to PM10 include effects on the respiratory and breathing systems, lung tissue damage, cancer, and early death. A significant rise in respiratory diseases has been observed in Delhi, the capital of India, as a result of air pollution, and the National Green Tribunal (NGT) and other medical experts have issued health advisories for the city's residents. When symptoms of pulmonary illness first show, preventative or therapeutic interventions are more likely to be successful [2]. Pulmonary disease can also be identified by routine testing [9].

Nov 15, 2018, the 36 monitoring stations that make up the current AQI index classify Delhi as poor with a PM2.5 index value of 217. When people are exposed to hazardous chemicals and gases from vehicle emissions over an extended period, their lungs and airways get irritated and allergic to them. Individuals who spend years working near busy traffic lights and other occupationally exposed regions are at danger from air traffic pollution, which over time may cause illnesses like asthma and bronchitis and alter normal lung functioning. It would not be accurate to argue that those who work in indoor surroundings are immune to the potentially dangerous impacts of high environmental pollution given the deteriorating pollution levels.

There is a need to raise awareness that not only those who are directly exposed to air pollutants but also those who stay indoors are at risk due to Delhi's high levels of environmental pollution because it would not be fair to say that people who work in indoor environments are exempt from these harmful effects.

Due to the fact that CISF metro staff members have one of the most physically demanding jobs, it was necessary to evaluate their physical condition after employment [4]. Vehicle emissions, industrial processes, and the burning of agricultural products have all been linked to air pollution in Delhi, both indoors and out [10–14]. This observational and cross-sectional study aims to assess the pulmonary functions of CISF staff of Delhi Metro who are working in indoor environmental conditions at different areas of Delhi.

MATERIAL AND METHODS

This observational/cross-sectional study was conducted in accordance with national ethical guidelines for biomedical and health research and included the Indian Council of Medical Research (2017) and Declaration of Helsinki (2013) guidelines for human subjects. A total of 391 subjects (mean age = 29.86, mean height = 168.99, mean weight = 69.13) participated in the study (sample size calculated from Epi-info) from Dwarka and Mahipalpur (West Delhi), Rithala (North Delhi), from Okhla. and Jasola (South Delhi) and Shastri Park (East Delhi). Image 1 shows the subject distribution from each region. Subjects were normal (physically and mentally fit), non-smokers aged 18-45, mainly working indoors, normal BMI. Patients with chronic obstructive pulmonary disease, asthma, musculoskeletal abnormalities, tuberculosis, heart disease, anemia, obesity and smoking, with a history of angina or chest pain, diabetes or hypertension, uncooperative individuals unable to perform pulmonary function tests, implanted pacemakers and stents. Pregnant workers were excluded from the study if they should not have used inhalers and nasal sprays. The sampling method was convenience sampling.

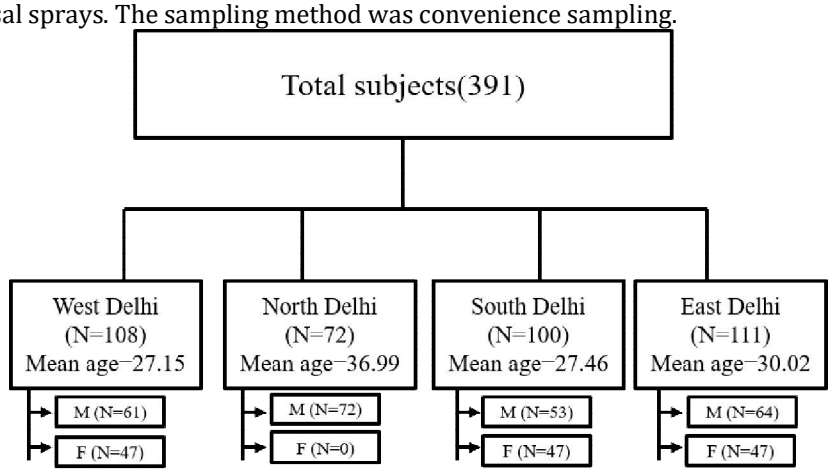

Figure 1: Flow chart showing subject distribution

Ethical approval: The study proposal was approved by university ethics committee (Research development committee of school of physiotherapy affiliated to the university) on the 11-December-2018. The permission letter to CISF DMRC was sent on the date 9-January 2019.

Procedure

On paper informed consent was taken from all subjects before starting the data collection, after explanation about the study, need and benefits to the society in general. Subjects were explained the entire procedure of the test. Demographic details and thorough history was taken of each subject, respiratory history and personal history was taken in detail to note about any previous respiratory ailments and any habits of smoking etc.

The outcome measures Forced Vital capacity (FVC), Peak expiratory flow rate (PEFR), Forced expiratory volume in 1 second (FEV_1) , Forced expiratory volume in 1 second/forced vital capacity(FEV_1/FVC) and Forced expiratory flow 25–75% ($FEF_{25–75\%}$) were measured by PFT Machine by RMS, Helios-401 Model which is a hand-held apparatus consisting of a turbine transducer housed within the main unit and was connected to a detachable mouthpiece. Pulses generated by the volunteers were picked up by the sensitive transducer amplifies and forwards the information to the Microcontroller. The pulses were visible in the form of graphical representation in the attached desktop. Other instrumentation used was weighing machine, Stadiometer and Disposable mouth pieces for each individual. The procedure used and the apparatus was reliable and had been validated as stated by the user manual of the Helios 401 (Recorders & Medicare Systems (P) Ltd.(Figure 2)).Permission from CISF DMRC Head was taken for the conduction of the study. Ethical approval from the research and ethics committee of the school of physiotherapy, Delhi Pharmaceutical sciences and Research University was taken. Pulmonary function testing was done by RMS Helios model 401 and the Forced vital capacity, Slow vital capacity and Maximum voluntary ventilation were recorded for all the selected subjects.

Data collection was done in the month of February 2019 at different places in Delhi for males and females which were East Delhi -Male population: Shastri park CISF DMRC headquarter and males hostel, Female population: Shastri park CISF DMRC headquarter and females hostel, West Delhi- Male population: Dwarka CISF DMRC office near kakrola village and males hostel, Female population: CISF complex mahipalpur bypass road, DMRC lady hostel Barrack 3, North Delhi – Male population only at CISF males hostel near Rithala metro station, South Delhi – Male population: CISF camp Harkesh Nagar Okhla, near Govind Puri metro station Female population: Girls CISF camp Jasola. Figure 3 shows an image of CISF personnel performing PFT.

Figure 2: Pulmonary function test machine- Helios 401

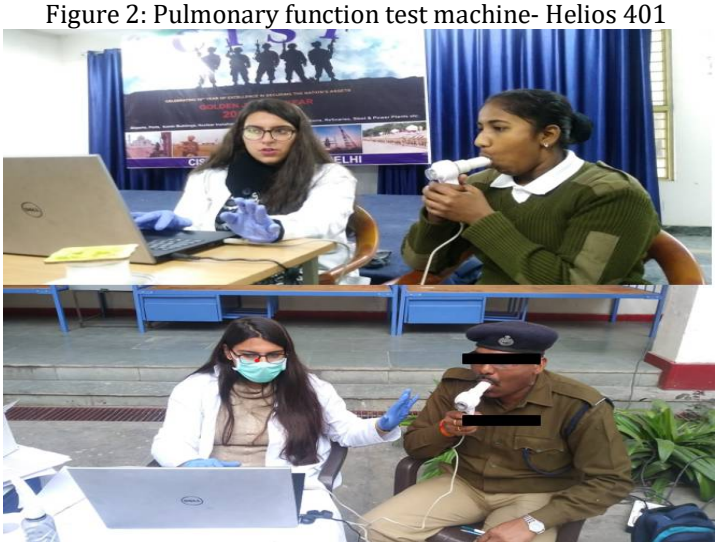

Figure 3: CISF personnel performing the pulmonary function test

Statistical Analysis

Data was analyzed at the School of Physiotherapy, DPSRU by using SPSS version 16.0. One way ANOVA was used to compare the generated PFT values of subjects in different zones of Delhi. Chi square test ($p<0.01$) was used to compare the distribution of subjects with normal and abnormal PFT values (compared with predictive values for each subject by RMS, Helios-401 Model) in different zones of Delhi. Bonferroni adjustment was used post hoc to prevent data from incorrectly appearing to be statistically significant.

RESULTS

The study conducted among CISF DMRC staff (mean age 24.85 years) revealed a decline in the PFT parameters (FVC, PEFR, FEV_1, FEV_1/FVC and $FEF_{25-75\%}$) when compared to the predictive values (machine generated). Among the total population screened from different zones of Delhi, **35.54%** showed obstruction, **8.43%** exhibited restriction, **1.53%** showed mixed blockage. Also **59.33%** of the total subjects revealed early small airways obstruction in lungs. ANOVA analysis revealed significant differences in values of FVC, FEV1 and PEFR in different zones of Delhi ($p<0.001$). On the other hand, FEF_{25-75} (p value=0.233) was found to be insignificantly different in the zones of Delhi (Table 1).As per multiple comparison (Bonferroni test) FVC and FEV1 of North Delhi was significantly different from that of West and South Delhi.Also, PEFR of West Delhi was significantly different from that of North and East Delhi (Table 2).

Chi square test revealed that there exists a significant difference in distribution of subjects with normal and abnormal PFT values when different zones of Delhi are concerned (p value< 0.001) (Table 3). .Further, West Delhi showed the highest ratio of normal individuals in comparison to North (OR-3.25), South (OR- 1.72) and East (OR- 2.62) Delhi (Table 4).

DISCUSSION

PFTs are non-invasive diagnostic procedures that offer quantifiable information regarding the health of the lungs. For clinical diagnosis and research reasons, an evaluation of lung volumes, capacities, and flow rates provides particular information. The definition of safe circumstances and the evaluation of the consequences of exposure to recognized dangers are based on studies of PFTs in employees in various occupations [15].

This is the first study by far done on CISF metro staff and the external validity is ensured by collection of data from different parts of Delhi region for both male and female CISF staff.

In the current study, at Shastri Park (East Delhi), among 111 subjects (male and female) screened, 39.63% had mild to severe obstruction and 9.90% had lung restriction, 2.7% had mixed obstruction and 72.07% had early small airway obstruction. with any obstruction or restriction in certain subjects.In Rithala (North Delhi), out of 72 subjects (males) screened, 37.5% had mild to severe obstruction, 23.61% had lung restriction, 1.38% had mixed obstruction, 66.66% had early small airway obstruction associated with obstruction or restriction. in certain subjects.

In Okhla/Jasola (South Delhi), out of 100 subjects (male and female) screened, 34% had mild to severe obstruction, 3% had lung restriction and 1% had mixed obstruction, 58% of all subjects had early small airway obstruction with any obstruction or restriction in some subjects. Of the 108 subjects screened in Dwarka/Mahipalpur (West Delhi), 31.48% had mild to severe obstruction, 1.85% had lung restriction, 0.92% had mixed obstruction and 42 people.Fifty-nine percent of subjects had early small airway obstruction, with obstruction or restriction in some subjects.

Thus, the highest number of lung obstructions was found in Shastri Park staff, followed by Rithala, and the highest number of lung restrictions was found in Rithala. Based on gender, height and weight, Dwarka/Mahipalpur had the highest number of subjects with spirometry below the normal limit i.e. 65.74%, followed by Okhla with 62 % of subjects within normal spirometry range.

These data show that CISF DMRC staff working and living in Shastri Park (East Delhi) and Rithala (North Delhi) are at higher risk of air pollution even when working in an indoor environment and not not directly exposed to traffic pollutants, compared to less affected CISF DMRC staff from Okhla/Jasola (South Delhi) and less affected CISF DMRC staff from Dwarka/Mahipalpur (West Delhi).

In reading this conclusion, one could also consider how ageing affects lung function metrics physically, yet the screening device utilised in this study makes projections based on the individual's age, height, and weight and provides interpretations in accordance with those predictions.

As outdoor occupations in general are hazardous due to prolonged exposure to high concentrations of vehicular pollution, putting them at an increased risk of respiratory and cardiovascular disease, numerous studies have been conducted in the past on traffic policemen, drivers, and other individuals with outdoor occupations [16].

In the present study, there may be other reasons attributing to decreased lung functions secondary to air pollution but the substantial rise of air pollution over the last few years in Delhi cannot be ignored making the study necessary and significant.

FVC and FEV1 are used to distinguish between obstructive and restrictive patterns of lung disease. In obstructive lung disease, FEV1 is disproportionately lower than FVC, reducing the FEV1/FVC ratio. In restrictive lung diseases, FEV1 decreases disproportionately to FVC, so the FEV1/FVC ratio increases.

The current study aimed to determine whether people who work in indoor environments are vulnerable to pollution, as most pollution research is based on outdoor work. After measuring the PFT of CISF staff working in Delhi Metro from different districts, it can be seen in this study that people working in more polluted areas have a greater impact according to AQI data.

The AQI of Shastri park and Rithala is worse and has even deteriorated in winter months of November and December (WHO). This trend has been constantfor the past couple of years. On the contrary AQI of Dwarka and Mahipalpur is better due to the areas still under developed and large areas are barren land and have a few trees and vegetation.

Thus there is an effect of areas AQI on the working population irrespective of the fact that whether they are in direct exposure or not. To a certain extent, even the individuals working in the indoor occupational workspace and those not directly exposed suffer from deterioration in the pulmonary health and lung capacities due to alarming rising air pollution levels.

In a previous study of non-smoking traffic police, VC ($P<0.05$), FEV1 ($P<0.01$), FEF-25 ($P<0.05$) and PIF ($P<0.05$) were significantly higher than those of non-smokers. decrease. study group to the control group.In smokers, VC ($P<0.05$), FEV1 ($P<0.0001$), PEF ($P<0.0001$), MVV ($P<0.0001$), FEF-25 ($P<0$) were significantly decreased.0001) and PIF ($P<0.01$) in the study group compared to the control group. These changes indicated that traffic police officers had limited lung expansion, obstruction, and constricted airways compared to regular police officers. This has been attributed to years of exposure to hours of daily vehicle pollution leading to reduced lung function, exacerbated by chronic smoking [17].

However, there are other studies that contradict the results of this study. Attfield et al observed that regardless of There was no significant difference in FVC between miners whether they were smokers or non-smokers. Kesava Chandrani et al also reported in their study of gas pump workers that the age regression coefficient was not significant for all PFT except PEFR [15].

Karieta et al found that no consistent trend of lower lung function was observed in traffic officers [18]. After the authors controlled for age, height, and smoking index, Bangkok police had a significantly lower mean forced expiratory volume in 1 second and a forced expiratory flow rate at 25% of vital capacity (025w) than the Ayutthaya police. Multiple regression analysis identified age and workplace as statistically significant factors affecting forced expiratory volume in 1 second. This study provides evidence of an increased incidence of obstructive airway changes around traffic police in Bangkok.

Based on the data obtained in this study, awareness needs to be spread among people working in indoor environments, especially CISF DMRC personnel, who serve their country at the expense of their own health. As a physiotherapist, it is important to suggest new physiotherapy measures such as breathing exercises that can benefit these people, but also to advise them to opt for the earliest preventative measures to maintain optimal respiratory health. There should also be regular assessments of those who work for civilians day in and day out, and their health should not be taken for granted.

A limitation of the study may be the inclusion of a convenience sample of CISF DMRC staff, which may be due to the limited time available during the workday for data collection for all respondents who work without interruption day after day. The sample size was insufficient due to the inability of staff and personnel to predict the type of damage in a particular area of Delhi, which itself is very large.Not all CISF DMRC camps and barracks are covered to check for any depreciation. The number of people studied may be small compared to the total population involved in the profession to predict the trends of the results representative of this population. Measuring daily pollution levels by any hand-held device is beyond the scope of this study. There is no CISF women's camp in North Delhi, so only the male population was screened in Rithala. Shift work may also explain the difference, as pollution levels differ day and night.

Therefore, future studies could be used to measure PFT in other people's indoor occupations. Follow-up research can be done to find new physiotherapy approaches that would benefit these subjects. Raising awareness of the health aspects of pollution and the use of protective equipment in the form of masks can also improve the situation. The effects of pollution levels and increasing age can be seen as they lead to physiological changes with age. Differences between smokers and non-smokers to see if lung health is affected by air pollution or smoking.Other factors that may contribute to worsening PFT in indoor environments should be investigated, and CISF DMRC staff should also be periodically reassessed.

Table 1: Depicting the mean and SD of the pulmonary parameters as measured in different areas along with the One way ANOVA analysis

Pulmonary parameters	Area of investigation	Total sample	Mean(SD)	ANOVA Analysis	
				F Value	P Value
FVC	West Delhi	108	108.4(16.3)	5.704	0.001*
	North Delhi	72	97.9(24.9)		
	South Delhi	100	108.7(19.4)		
	East Delhi	111	105.0(20.1)		
	Total	391	105.0(20.15)		
FEV1	West Delhi	108	106.7(19.6)	12.028	0.001*
	North Delhi	72	89.3(22.5)		
	South Delhi	100	104.5(18.5)		
	East Delhi	111	98.5(21.9)		
	Total	391	100.6(21.4)		
FEF_{25-75}	West Delhi	108	82.37(28.6)	1.433	0.233
	North Delhi	72	74.1(34.8)		
	South Delhi	100	76.4(27.6)		
	East Delhi	111	75.4(31.3)		
	Total	391	77.4(30.4)		
PEFR	West Delhi	108	78.8(15.9)	12.094	0.001*
	North Delhi	72	69.2(22.0)		
	South Delhi	100	70.5(18.4)		
	East Delhi	111	63.6(19.6)		
	Total	391	70.6(19.6)		

(FVC- Forced Vital Capacity; FEV1-Forced expiratory volume in 1 second; FEF_{25-75}Forced expiratory flow 25–75%;PEFR- Peak expiratory flow rate)
*. The mean difference is significant at the 0.05 level.

Table 2 Multiple Comparisons (Bonferroni Test)

Dependent variable	Area(I)	Area(J)	Mean difference (I-J)	Std. Error	Sig.
FVC	1	2	10.50*	3.01	.003*
		3	-.29963	2.75	1.00
		4	5.44	2.68	.256
	2	3	-10.78*	3.06	.003*
		4	-5.05	2.10	.555
	3	4	5.74	2.3	.22
FEV1	1	2	17.41*	3.13	.000*
		3	2.23	2.85	1.00
		4	8.27*	2.78	.019
	2	3	-15.19*	3.18	.000*
		4	-9.15	3.11	.021
	3	4	6.03	2.83	.204
FEF	1	2	8.22	4.61	.455
		3	5.92	4.21	.965
		4	6.97	4.10	.540
	2	3	-2.30	4.62	1.00
		4	-1.25	4.60	1.00
	3	4	1.05	4.19	1.00
PEFR	1	2	9.63*	2.86	.005*
		3	8.29	2.61	.010
		4	15.20*	2.54	.000*
	2	3	-1.34	2.91	1.00
		4	5.57	2.85	1.00
	3	4	6.91*	2.59	.049

(FVC- Forced Vital Capacity; FEV1-Forced expiratory volume in 1 second; FEF_{25-75}Forced expiratory flow 25–75%;PEFR- Peak expiratory flow rate)
*. The mean difference is significant at the 0.05 level.

Table 3 Chi Square Test

	Value	Df	Asymp. Sig.(2 sided)
Pearson Chi-square	17.245	3	.001*
Likelihood ratio	17.183	3	.001*
N of valid cases	391		

*. The mean difference is significant at the 0.05 level.

Table 4: Presenting total individuals screened by PFT in different areas of Delhi and the Number of subjects with abnormal and normal PFT in each area. The table also displays odds ratio

Area of Investigation	Total samples	PFT		Odds Ratio
		Abnormal	Normal	
West Delhi	108	56	52	
North Delhi	72	56	16	3.25
South Delhi	100	65	35	1.72
East Delhi	111	82	29	2.62
Total	391	259	132	

CONCLUSION

The conclusion drawn from the current study is that the residents of Delhi, especially CISF DMRC employees, are equally susceptible to the impacts of air pollution and that there is a decline in lung parameters among them whether they work in direct exposure or indoor settings. The level of pollution in a particular area is an indicator of the respiratory health of the people working in that area. It was seen that the CISF metro staff working in indoors environments are no more saved from the deleterious effects of air pollution.

This data indicated that CISF DMRC staff working and residing in Shastri Park (East Delhi) and Rithala (North Delhi) are furthermore susceptible to the hazards of worsening air quality even after working in indoor environments and not in direct exposure of traffic pollutants in contrast to DMRC staff of Okhla/Jasola(South Delhi) who are less affected and DMRC staff of Dwarka/Mahipalpur (West Delhi) who are least affected. Thus, there is an effect of areas AQI on the working population irrespective of the fact that whether they are in direct exposure or not. To a certain extent, even the individuals working in the indoor occupational workspace and those not directly exposed suffer from deterioration in pulmonary health and lung capacities due to alarming rising air pollution levels.

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REFERENCES

1. Ghose MK, Paul R, Banerjee RK. (2005). Assessment of the status of urban air pollution and its impact on human health in the city of Kolkata. Environmental Monitoring and Assessment. 108:151-67.
2. Makwana, A. H., Solanki, J. D., Gokhale, P. A., Mehta, H. B., Shah, C. J., & Gadhavi, B. P. (2015). Study of computerized spirometric parameters of traffic police personnel of Saurashtra region, Gujarat, India. *Lung India: official organ of Indian Chest Society*, *32*(5), 457.
3. Ghosh N, Xi S, Sherali N, Hiranuma N, Banerjee P, Sherali S, Romero R, Rogers J, Vitale J, Revanna C, CIH M. (2018). Air pollution with 2.5 micron particulate matters and testing the decay of the aerosol concentration as a function of time to compare the efficiency of AHPCO® and Bi-Polar units in reducing the indoor particle counts. European Scientific Journal, 26-40.
4. Patil PJ, Thakare GV, Patil SP. (2013). Comparative study of lung function test of policemen in traffic control with those in general duty. Natl J Physiol Pharm Pharmacol. 3(2):162-6.
5. Sagar A, Bhattacharya M, Joon V. (2007). A comparative study of air pollution-related morbidity among exposed population of Delhi. Indian Journal of Community Medicine. ;32(4):268-71.
6. Crebelli R, Tomei F, Zijno A, Ghittori S, Imbriani M, Gamberale D, Martini A, Carere A. (2001). Exposure to benzene in urban workers: environmental and biological monitoring of traffic police in Rome. Occupational and environmental medicine.;58(3):165-71.
7. Sydbom A, Blomberg A, Parnia S, Stenfors N, Sandström T, Dahlen SE. (2001). Health effects of diesel exhaust emissions. European Respiratory Journal. ;17(4):733-46.
8. Rizwan SA, Nongkynrih B, Gupta SK. (2013). Air pollution in Delhi: its magnitude and effects on health. Indian journal of community medicine: official publication of Indian Association of Preventive & Social Medicine. ;38(1):4.
9. Pramila T, Girija B. (2013). Study of pulmonary function tests in traffic policemen exposed to automobile pollution in Bangalore City. Nat J Basic Med Sci. 3:35-8.

10. Goyal R, Khare M. (2011). Indoor air quality modeling for PM10, PM2. 5, and PM1. 0 in naturally ventilated classrooms of an urban Indian school building. Environmental monitoring and assessment. ;176(1-4):501-16.
11. Kumar A. (2009). Lead loadings in household dust in Delhi, India. Indoor Air. ;19(5):414-20.
12. Kumar, A., Phadke, K. M., Tajne, D. S., & Hasan, M. Z. (2001). Increase in inhalable particulates' concentration by commercial and industrial activities in the ambient air of a select Indian metropolis. *Environmental science & technology*, *35*(3), 487-492.
13. Balachandran, S., Meena, B. R., & Khillare, P. S. (2000). Particle size distribution and its elemental composition in the ambient air of Delhi. *Environment International*, *26*(1-2), 49-54.
14. Solanki HK, Ahamed F, Gupta SK, Nongkynrih B. (2016). Road transport in Urban India: Its implications on health. Indian journal of community medicine: official publication of Indian Association of Preventive & Social Medicine. 41(1):16.
15. Raina, V., Sachdev, S., & Gupta, R. K. (2014). Study of Pulmonary Function Tests of Traffic Policemen In Jammu Region. *JK Science*, *16*(3), 122.
16. Kelishadi, R., & Poursafa, P. (2010). Air pollution and non-respiratory health hazards for children. *Archives of medical science: AMS*, *6*(4), 483.
17. Dutta T, Pal G. (2010). Pulmonary function test in traffic police personnel in Pondicherry. Indian J Physiol Pharmacol. 54(4):329-36.
18. Karita K, Yano E, Jinsart W, Boudoung D, Tamura K. (2001). Respiratory symptoms and pulmonary function among traffic police in Bangkok, Thailand. Archives of Environmental Health: An International Journal. 1;56(5):467-70.

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