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Original Article

To study the influence of occupational exposure to pollutants on respiratory symptoms and pulmonary function tests among automobile mechanics

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Abstract:

Background of the study: The study was carried to study the influence of occupational exposure to pollutants on respiratory symptoms and pulmonary function tests among automobile mechanics.

Methodology: The study group comprised of 100 male automobile workshop /garage workers (working for more than one year) including 67 non smoker garage workers and 33 smoker garage workers and 100 non smoker Control subjects. Chronic respiratory symptoms of the garage workers were recorded by using the ATS – DLD – 78 A recommended adult questionnaire on respiratory symptoms. The Pulmonary Functions of workers were assessed using spirometer (VITALOGRAPH COMPACT-Π).

Results: There was statistically significant decrease in Forced vital Capacity (FVC), Peak Expiratory Flow Rate (PEFR) ,Forced Expiratory Volume in first second(FEV1.0), FEV1.0/FVC ratio <80% and Forced Expiratory Flow at 25%-75% of volume as percentage of Vital Capacity (FEF 25%-75%). Smoker garage workers had higher frequency of chronic respiratory symptoms and lung function impairment as compared to non smoker garage workers.

Conclusion: People who are exposed to auto exhaust emission for more than 15 years are likely to develop mixed type of lung disease (both restrictive and obstructive pattern of respiratory function was evident in these garage workers) and smoking appeared to accelerate the decline in lung function.

Key words: Pulmonary Function Tests, FEV1.0 , PEFR , FEF 25%-75%, Garage workers, Spirometer

INTRODUCTION

The damaging effects of air pollution on man and the environment range from acid rains, global warming, ozone depletion and the direct effect on health of man especially respiratory health. Most of the diseases of lung are caused by inhalation of harmful matter like microorganisms, tobacco smoke allergens and other particles which are encountered in the general environment. Automobile mechanics or garage workers are a group of professionals exposed continuously to auto-exhaust and other pollutants at their workplace [1]. Occupational risks and hazards faced by these workers are: a) Skin diseases and conditions (various types of dermatitis, skin sensitization, eczema, oil acne, etc.) caused by various chemicals, e.g.: adhesives, asbestos, antifreeze and brake fluids, epoxy resins, gasoline, oils, nickel, colophon etc. , b) Eye irritation, dizziness, nausea, breathing problems, headaches, etc., caused by contact with irritating chemicals and their dusts and fumes, e.g.: antiknock agents (such as methylpentadienyl manganese tricarbonyl [MMT]), ketone solvents (such as methyl isobutyl keton [MIK]) etc. c) Asbestosis and mesothelioma caused by asbestos dust from brake drum cleaning and processing operation . Chronic poisoning resulting from exposure to lead and its dust and fumes (esp. while repairing radiators, handling storage batteries, welding, using paints and lubricants, etc). d) Hematological changes as a result of exposure to solvents, such as benzene and its homologues, toluene, xylene, etc.e) Increased risk of cancer due to inhalation of diesel exhaust fumes or contact with certain heavy metals and their compounds, asbestos, benzene etc. f) Increased risk of organic brain damage due to inhalation of diesel exhaust fumes. g) Acute eye and mucous membrane irritation, headaches, breathing difficulties, chest tightness etc., caused by inhalation of nitric oxide and respirable particulates [2]. The various lung responses that can occur to these irritant gases are acute bronchitis, airway hyperreactivity, bronchiolitis obliterans, asthma, reactive airway dysfunction syndrome (RADS), chronic bronchitis, emphysema, fibrosis, bronchial carcinoma, pleural mesothelioma, etc.

Pulmonary function test's (PFT's) are physiological tests i.e. they are tests of function. The PFT's are employed to assess the three basic processes of lungs – Ventilation, Diffusion and Perfusion. a). Ventilation function: These tests measure lung size (VC), patency of airways (MVV; FEV1.0) and alveolar ventilation using a spirometery. b) Gas Exchange/Diffusion Function: The efficacy of gas exchange in the lungs is measured by analysis of respiratory and blood gases. c) Perfusion Function: Special procedures like perfusion scan are employed for the study of blood flow through the lungs. Different diseases produce different patterns of abnormalities in the battery of pulmonary function tests.

Spirometery is invaluable as a screening test of general respiratory health [3]. It measures how an individual inhales or exhales volumes of air as a function of time. The most important aspects of spirometery are the forced vital capacity(FVC), which is the volume delivered during an expiration made as forcefully and completely as possible starting from full inspiration and the forced expiratory volume (FEV1.0) in one second, which is the volume delivered in the first second of an FVC maneuver. The ratio of FEV1.0 to FVC are obtained from, maximal forced and relaxed expirations into a recording spirometer and compared with predicted values based on age, sex, height and ethnic group. Typical patterns of abnormalities such as obstructive and restrictive ventilatory defects are obtained.

In India 52 % of adult males and 6% of adult females are smokers[1.] Smoking, its duration and frequency are established risk factors for the development of various respiratory diseases.

The present study used a questionnaire and measuring spirometry in automobile mechanics to assess the effects of occupational exposure on their respiratory health.

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OBJECTIVES

1. To study the pattern of respiratory symptoms in automobile mechanics.
2. To study the pulmonary function abnormalities in automobile mechanics and compare with healthy controls.
3. To study the influence of duration of occupational exposure on spirometric functions of the lung.

METHODOLGY

The present cross-sectional analytical study was conducted in Shimla city and its surroundings for the period of one year. A subject was defined as a male working in an automobile workshop /garage for one year or more. The controls were taken from healthy volunteers, who were never exposed to above mentioned occupational exposure. Matching was done in terms of age, height and weight. Informed written consent was taken from all the subjects willing to participate in the study. A minimum of 100 cases and 100 controls was included in the study.

The inclusion criteria were: a).Healthy male automobile mechanics in the age group of 20-50 yrs. b). Duration of occupational exposure for one year or more. The exclusion criteria were: a) historic or clinical evidence of pulmonary or heart diseases not related to occupational hazards (like Congenital heart disease, Coronary heart disease Rheumatic heart disease, Tuberculosis, Asthma, COPD, Diabetes mellitus, etc.). **b)** historic or clinical evidence of any neuromuscular illness likely to affect the performance of spirometric PFT's (e.g. limited joint mobility etc.).**c)** unable to perform acceptable and repeatable spirometery. **d)** past history of significant occupational history which could have bearings on PFT's (e.g. previous occupation in coal mines, quarries, cement plant etc.).

EVALUATION OF SUBJECTS:

After screening of subjects by exclusion criteria based on history and examination, details of subjects were recorded .The automobile mechanics were administered a standardized questionnaire, based on ATS-DLD-78A recommended adult questionnaire recommended for use in epidemiological studies of all respondents 13 or more years of age [4]. The method for asking the questions and the coding of the responses were as per the instructions given along with the questionnaire. The questionnaire had a section which included details of the subject such as name, age, sex and address. A complete section of the questionnaire was devoted to the smoking habits of the subjects. The number of cigarettes smoked per day and the duration of smoking were noted. Smoking index was computed by multiplying the number of bidis/cigarettes smoked per day by the number of smoking years. The presence or absence of respiratory symptoms of cough, sputum production, shortness of breath, wheezing and past chest illnesses were recorded in each subject using separate sections for each symptom in the questionnaire. For the purpose of study chronic bronchitis was defined as the presence of a cough, productive of sputum not attributable to other causes on most days, for at least 3 months over two consecutive years [5]. Occupational history (past and present) and its duration of exposure were recorded.

General Physical Examination including anthropometrical measurements (Height in centimetres, Weight in kilograms), general appearance, pallor, Lymphadenopathy, Blood pressure, Pulse rate, Respiratory rate was recorded. Detailed systemic examination including respiratory and cardiovascular system was done.

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Evaluation of controls:

After screening for exclusion criteria, the details pertaining to the History, General physical examination and systemic examination similar to subject were recorded.

INVESTIGATIONS:

1. Spirometric PFT's were done after recording all baseline parameters. The pulmonary function testing was done using an electronic portable PC based spirometer with printer (MODEL-VITALOGRAPH COMPACT-Π, BUCKINGHAM, ENGLAND). It fulfilled the accuracy and precision criteria as per American Thoracic Society (ATS) guidelines[6]. It has a Fliesch pneumotachograph type of flowhead , which detects instantenous expired and inspired respiratory air. Inside the flow head, there is a resistance in form of a series of parallel tubes, which maintain laminar flow in the air passing through it. This creates differential pressure which is measured by a transducer inside the instrument.

2. The subjects were instructed and demonstrated on how to perform the tests. The subject was made to sit and relax for approximately fifteen minutes prior to recording.

3. The subject was asked to perform the test in standing upright posture. First time they were instructed to take maximum inspiration and blow into the instrument rapidly and forcefully. Second time they were asked to take maximal inspiration and make a prolonged forceful expiration followed by re-inspiration from the mouth piece. A close watch was kept to ensure that a tight seal is maintained between the lips and the mouthpiece of the device, nose clip will be used. The parameters were recorded.

4. At least three readings were taken and the highest reading at any testing session was used in trend analysis. All values were corrected for body temperature, air pressure and water saturation (BTPS).

5. Spirometric data was recorded as a) Absolute measures. b) Percent of those predicted for age, sex and height.

6. The indices which were measured in the study included:

- Forced vital Capacity(FVC)
- Forced expiratory volume in one second($FEV_{1.0}$)
- $FEV_{1.0}$/FVC
- Peak expiratory flow rate (PEFR)
- Forced mid expiratory flow (FEF 25-75%)

STATISTICAL ANALYSIS

Frequency analysis was done to determine the prevalence of respiratory symptoms by various groups. Spirometric PFT results of the subjects and controls were compared using student's "t" test and the 'p' value computed against the degree of freedom.

RESULTS:

In the present cross-sectional study hundred automobile mechanics from various automobile garages in and around Shimla were the subjects of study. They were all males in the age group 20-50 years. For the purpose of comparison, another group of one hundred non-exposed males were enrolled as controls.

The anthropometric parameters of the exposed garage-workers and non-exposed controls are given in **table 1**. The two groups did not differ significantly on these parameters viz. age, height and weight.

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Pulmonary function test (PFT's):

The observed values of various PFT's were compared between the exposed garage workers and non exposed controls. **Table 2** shows the means of 'absolute measured values' of the PFT's of the two groups. The mean measured value of FVC in the garage workers was 3.11(± 0.8)*l* and the controls was 4.02 (± 0.93)*l*. It was significantly ($p<0.000$) less in the garage workers as compared to the controls. The mean measured value of $FEV_{1.0}$ in the garage worker was 2.69 (± 0.70)*l* and the controls was 3.45 (+ 0.87)*l*. It was significantly ($p<0.000$) less in the garage workers as compared to the controls. The mean percentage value of FEV1% in the garage workers was 87.01% (± 8.90) and the controls was 85.56% (±9.55). There was statistically no significant change in the mean value of $FEV1_{\%}$ in the garage workers in comparison to the controls. The mean measured value of PEFR in the garage workers was 437.83 (±128.43)*l*/min and the controls was 601.83 (+ 115.17)*l/min*. There was a statistically significant change ($p<0.000$) in the mean value of PEFR in the garage workers in comparison to that of the controls. The mean measured value of MMEF in the garage workers was 3.44 (± 1.02)*l* and the controls was 4.36 (± 1.08)*l*. There was a significant fall in the mean value of MMEF in the garage workers in comparison to the controls. There was significant decline in most of the PFT's of the garage workers in comparison to the controls . However FEV1% was more in the garage workers as compared to the controls , though insignificant **(Table 2)** .

In the garage workers there were 67 non-smokers and 33 smokers. To see the exclusive effect of occupational exposure, the PFT's of non smoker garage workers were compared with the controls. These two groups were comparable in terms of age and height .The parameters FVC, $FEV_{1.0}$, PEFR and $FEF_{25-75\%}$ were significantly less in the non-smoker garage workers as compared to controls. However, the ratio FEV 1% did not differ much in the two groups **(Table 3).**

In another intra group comparison to see for the effect of smoking, non smoker garage workers were compared with smoker garage workers. The mean of 'percentage of predicted' value for each of the PFT's was considered for the analysis to eliminate the effect of age and height. The predicted values for each individual were calculated from the regression equations for healthy Indian males. Significant($p<0.05$) decline was seen for $FEF_{25-75\%}$ and PEFR of the smokers garage workers in comparison with the non smokers **(Table 4)** .

To study the effect of duration of exposure on PFT's of the garage workers, the garage workers were further subdivided into four subgroups namely (Group A): with duration of exposure 5 years or less; (Group B): with duration of exposure 5.1 to 10 years; (Group C): with exposure duration of 10.1 to 15 years and (Group D): with exposure duration of 15 years or more **(Table 5).**

Means of 'percentage of predicted values' for PFT parameters in the exposed garage workers are given in **table 6**. A gradual decline was seen in the parameters with increased duration of exposure. It was statistically significant ($p<0.05$) for parameters FVC, $FEV_{1.0}$ for group who had been exposed for more than 15 years in comparison to group exposed for less than 5 years. $FEF_{25-75\%}$ declined gradually with increased duration of exposure and it was significant ($p<0.05$) when the group with exposure less than 5 years was compared to the group with exposure between 10 to 15 years. PEFR and FEV 1% showed no significant changes with exposure duration.

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RESPIRATORY SYMPTOMS

Chronic respiratory symptoms of the garage workers were recorded by using the ATS – DLD – 78 A recommended adult questionnaire[4] on respiratory symptoms.

There were in total 34 symptomatic garage workers with one or more symptoms **(Table 7).**

There were 67 non smoker garage workers and 33 smoker garage workers. A separate analysis of the prevalence of chronic respiratory symptoms by smoking in the garage workers demonstrated a higher prevalence of chronic respiratory symptoms in the smokers than in the non smokers garage workers. All the differences were however non significant **(Table 8).**

There were 46 garage workers with duration of exposure less than 10 years and 54 garage workers with duration of exposure more than 10 years. An analysis of the prevalence of chronic respiratory symptom by the duration of exposure (<10 years and more than 10 years) demonstrated a higher prevalence of almost all symptoms for workers employed for more than 10 years than for those with a shorter history of employment although these differences were significant only for cough in the garage workers **(Table 9).**

Table-1

Anthropometric parameters and average duration of exposure of garage workers and controls

Sr. No.	Characteristics	Garage Workers Mean (± SD)	Controls Mean (±SD)	p-value
1.	Number of Subjects	100	100	
2.	Age in years	32.19 (±8.92)	32.36 (±8.62)	0.891
3.	Height in Cms.	165.42 (±7.150)	167.16 (±6.237)	0.068
4.	Weight in Kgs.	58.80 (±6.470)	62.45 (±8.201)	0.06
5.	Residence	Urban	Urban	
6.	Duration of Exposure (years)	11.6		

Note: p-value < .05, significant

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Table-2

Comparison of the PFT's of the Garage Workers and the Controls

Sr. No.	Parameters	Garage Workers Mean (±SD)	Control Mean (±SD)	p-Value
1.	FVC (*l*)	3.11 (±0.86)	4.02 (±0.93)	0.000**
2.	$FEV_{1.0}$ (*l*)	2.69 (±0.70)	3.45 (±0.87)	0.000**
3.	$FEV_{1.0}$/FVC %	87.01 (±08.90)	85.56 (±09.55)	0.268
4.	PEFR (*l/min*)	437.83 (±128.43)	601.38(±115.17)	0.000**
5.	FEF 25-75% *(l/sec)*	3.44 (±1.02)	4.36 (±1.08)	0.000**

Note: p-value <.05, significant

Table – 3

PFT's of the non-smokers garage workers and controls

Sr. No.	Parameters	Non smokers (Garage workers) Mean (±SD)	Controls Mean (±SD)	Significance
1.	Number	67	100	
2.	Age (years)	30.37(± 8.61)	32.36 (± 8.61)	0.146
3.	Height (cms)	165.27 (± 7.69)	167.16(± 6.23)	0.082
4.	Weight (kgs)	58.85 (± 6.73)	62.09 (± 7.77)	0.006
5.	FVC (*l*)	3.15 (± 0.89)	4.02 (± 0.93)	0.000
6.	$FEV_{1.0}$ (*l*)	2.75(± 0.70)	3.45(±0.87)	0.000
7.	FEV 1%	88.05(± 9.08)	85.56(± 9.55)	0.095
8.	PEFR (*l/min*)	456.21(±121.42)	601.38(±115.18)	0.000
9.	$FEF_{25-75\%}$ (*l/sec*)	3.54(±1.05)	4.36(±1.08)	0.000

p value <0.05, significant

Table – 4

Comparison of the PFT's of smoker garage workers with the non smoker garage workers

Sr. No.	Parameters	Smokers Mean (±SD)	Non smokers Mean (±SD)	Significance
1	FVC *(I)*	84.45(± 22.00)	83.84(±23.14)	0.899
2	$FEV_{1.0}$ *(I)*	85.60(±24.55)	86.86(±21.09)	0.791
3	FEV1%	84.90(±8.26)	88.05(±9.08)	0.098
4.	PEFR *(l/min)*	76.57(±26.48)	84.67(±22.60)	0.030
5.	$FEF_{25-75\%}$ *(l/sec)*	74.27(±21.72)	77.73(±21.74)	0.050

p value <0.05, significant

Table – 5

Physical parameters and average duration of exposure of Garage workers

Parameters	Group A Mean (± SD)	Group B Mean (±SD)	Group C Mean (±SD)	Group D Mean (±SD)
Number(n)	23	27	13	37
Age(years)	23.60 ± 2.5	26.44± **3.00**	31 ± **6.90**	39.3 ± **7.8**
Height(cms)	162.37 ± **8.12**	167.33 ± **7.49**	167.00 ± **1.0**	165.37 ± **4.40**
DOE	2.7 ± **1.4**	6.8 ± **2.0**	12 ± **1.9**	18.1 ± **3.9**

Table – 6

Percentage predicted values of PFT's of the exposed group according to DOE

Sr. No.	Parameters	Group A Mean (± SD)	Group B Mean (±SD)	Group C Mean (±SD)	Group D Mean (±SD)
1.	FVC *(l)*	85.39(±17.13)	83.22(±21.00)	82.76(±22.50)	80.16(±26.77)*
2.	$FEV_{1.0}$ *(l)*	88.56(±17.56)	82.89(±22.52)	83.92(±19.64)	81.62(±20.68)*
3.	FEV1%	103.52(±5.81)	98.79(±5.57)	101.20(±7.28)	101.5(±7.87)
4.	PEFR *(l/min)*	88.26(±16.51)	81.63(±21.72)	78.76(±29.79)	78.72(±27.74)
5.	$FEF_{25-75\%}$ *(l/sec)*	79.47(±23.79)	77.74(±22.01)	74.23(±14.82)#	69.78(±22.64)*

significant (p<0.05) in comparison of group A with C

* significant (p<0.05) in comparison of group A with D

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Table – 7

Prevalence of chronic respiratory symptoms in the garage workers

Sr. No.	Symptoms	n = number of garage workers	Percentage (%)
1.	Cough	12	(12)
2.	Sputum	14	(14)
3.	Shortness of breath	16	(16)
4.	Wheeze	1	(1)
5.	Chronic bronchitis	5	(5)

Table – 8

Prevalence of Respiratory Symptoms in Garage workers by smoking habit.

Sr. No.	Symptoms	67 Non Smokers n (%)	33 Smokers n (%)	Chi Value	P Value
1	Cough	6 (8.96)	6 (18.18)	3.2	.20
2.	Sputum	7 (10.45)	7 (21.21)	3.82	.15
3.	Shortness of breath	8 (11.94)	8 (24.24)	2.5	.29
4.	Wheeze	1 (1.49)	-	.49	.78
5.	Chronic bronchitis	1 (1.49)	4 (12.12)	3.25	.071

Note:- P value <0.05, significant

Table – 9

Prevalence of Respiratory Symptoms of Garage workers by duration of exposure

Sr. No.	Symptoms	<10 years	>10 years	Chi value	p-value
		n (%)	n (%)		
1.	Sputum	5 (10.86)	9 (16.67)	1.33	0.25
2.	SOB	6 (13.04)	10 (18.51)	1.19	0.27
3.	Wheeze	1 (2.17)	-	1.01	0.31
4.	Cough	3 (6.52)	9 (16.67)	3.41	0.05*
5.	Chronic bronchitis	2 (4.3)	3 (5.56)	.076	.782

Note: P value <.05, significant

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DISCUSSION

In the present study, the pulmonary functions and respiratory symptoms were investigated in one hundred garage workers employed in various automobile garages in and around Shimla who were apparently exposed to high levels of air pollution at their workplace for long durations. This study showed that chronic exposure to air pollution in the automobile garages due to automobile exhausts, fuel vapours etc adversely affected pulmonary function and increased frequency of respiratory symptoms.

For the purpose of comparison another group of one hundred healthy non-exposed males were enrolled as controls for the study. They were matched for age, height and weight to remove any confounding because of these variables which affect the pulmonary functions.

Spirometry was performed and parameters studied were (FVC), ($FEV_{1.0}$), ($FEV_{1.0}$/FVC), (PEFR) and ($FEF_{25to75\%}$). To assess the prevalence of respiratory symptoms ATS questionnaire were distributed to the garage workers and their responses were recorded.

In our study the prevalence of chronic respiratory symptom of cough in mechanics was 12%, sputum production was 14%, shortness of breath in our study had a prevalence of 16% and chronic bronchitis had a prevalence of 5% (**Table 7**). In a similar study Zuskin et al.(1994)[7] reported prevalence of cough in the mechanics was 21%, sputum 16.8%, shortness of breath 9.2%, chronic bronchitis 13.4% respectively. In our study there was just one case of asthma, whereas the other study has reported prevalence of 10% asthma in garage mechanics[7.] Epidemiologic studies have shown that cough, sputum production, dyspnoea, chest tightness were associated with motor vehicle exhaust emissions. [7, 8,9,10] Similarly, in our study prevalence of some respiratory symptoms viz. sputum production, shortness of breath were nearly same which could be attributed to exposure to auto exhaust.

A separate analysis by smoking habit in our study demonstrated that smokers had higher prevalence of chronic respiratory symptoms than nonsmokers **(Table 8).** Similar results have been reported in other studies. [7, 11] Chronic bronchitis is related much strongly to smoking than to atmospheric pollution.[12] Cigarette smoke causes release of proteolytic enzymes from lung neutrophils and macrophages. NOX contained in smoke caused emphysema in animals and oxidants in smoke reduced the levels of alpha-1 antitrypsin in humans and animal lungs. [13]

In our study garage worker employed for more than 10 years demonstrated a higher prevalence of chronic respiratory symptoms than those with shorter employment, suggesting a cumulative effect of this exposure **(Table 9).** Similar effects have been reported by studies other. [7, 11]

In the present study most of the parameters were significantly decreased in the garage workers as compared to controls.

The forced vital capacity of all the garage workers was significantly lower ($p<0.000$) than the controls. FVC can decrease by an interstitial process or by chest will destruction, known as restrictive ventilatory defect. Similar effects of automobile exhaust on FVC have been reported in the studies on tunnel and bridge workers, traffic wardens, shopkeepers and petrol pump workers. In these reports the subjects were exposed to exhausts for longer periods of time (more than a year, for at least 10 hours/day). [11,14,15] Contrary to this, the other study found no significant changes in FVC in a study where volunteers were subjected to short-term exposures to diesel exhaust. Automobile exhaust includes oxides of nitrogen (NOX), carbon monoxide, sulfur dioxide (SO_2), hydrocarbons and particulate matter (pm). Particulate matter of the size of 2.5 μ and 10 μ (pm2.5 & $pm_{1.0}$) and NO_2 have been found to be significantly associated with reduced FVC. [16]

The forced expiratory volume in the first second of FVC was significantly less ($P<0.000$) in the garage workers when compared with the non-exposed controls. $FEV_{1.0}$ is usually decreased in obstructive airways due to mucus secretion, bronchospasm, inflammation, or loss of elastic support of the airways themselves as in emphysema. Similar effects of automobile exhaust on $FEV_{1.0}$ have been reported in studies on tunnel and bridge workers, traffic wardens, shopkeepers and petrol pump workers. [11,14,15,17] By contrast, a study reported that observed changes in $FEV_{1.0}$ & FVC in tunnel and turnpike workers were unrelated to automobile exhaust exposure. [18]

In our study both parameters, $FEV_{1.0}$ and FVC were significantly less in the garage workers when compared with the controls. Interestingly the FEV 1% was more in the garage worker than the controls, though statistically insignificant. As both FVC and $FEV_{1.0}$ decrease proportionately, there was normal or even an increase in FEV 1%. This was hallmark of restrictive lung disease. Our finding suggested that the garage workers could have restrictive nature of pulmonary defect. The studies also found that restrictive types of impairments were more common amongst the automobile garage workers. [17, 19] It was reported that exposure to auto exhaust produced both restrictive and obstructive pulmonary impairment.[17, 20]

Particles generated from diesel exhaust are extremely small and are present in the nuclei or accumulation modes, with diameters of 0.02 mm and 0.2 mm respectively. Exposure to particulate matter of the size that penetrates to the alveoli combined with exposure to an irritant gas such as NO_2, SO_2 results in greater damage to the lung than when exposure occurs to either substance alone.NO_2 reduces mucociliary clearance and affects alveolar macrophage function.

In our study PEFR of the garage workers was significantly ($p<0.000$) less than the controls. The results of our study are consistent with other studies .[8,9,14,21] Peak expiratory flow is used to assess functional status of the airways. This flow rate is highly effort dependant and within the subject variability has been documented. This serves best as a monitoring tool for self evaluation by asthmatics. Decreased PEFR can result from even slightly sub-maximal effort or when maximal effort is made, it can decrease due to moderate to severe obstruction of large airways. Inhalation of high concentrations of SO_2 has been repeatedly shown to increase airways resistance in healthy human volunteers .[22,23,24] Auto exhaust is a complex mixture of very small particles (90%< 1 μg by mass) which can induce non specific airway hyper responsiveness and enhance the inflammatory response to an allergen challenge. [25, 26]

In our study this parameter was significantly ($p<0.000$) less in the garage workers as compared to the controls. Similar significant associations between $FEF_{25\text{-}75\%}$ and automobile exhaust pollution were found in other studies. [7,8,9,14,19,20] The findings in the present study indicated that small airways of garage workers were also the site of involvement in air pollution and fuel vapors related lung injury. $FEF_{25\text{-}75\%}$ is a flow at low volumes and indicates flow rates in small airways. Also known as Maximal Mid-Expiratory Flow rate (MMEF).It is considered a good test to identify early small airways disease airways (with internal diameter of less than 2 mm). These are reduced at low lung volumes both in restrictive and obstructive diseases. [9, 10] The gaseous pollutants alter the properties and concentration of surfactant and thus contribute to the early closure of small airways. Many terminal bronchioles may

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be compromised before other tests of pulmonary function such as $FEV_{1.0}$ are affected. Terminal bronchioles are probably the earliest site of pollutant induced injury.

EFFECT OF SMOKING ON PFT's

In our study the comparison of non-smokers with the smoker garage workers showed PEFR significantly ($p<0.03$) lower in the latter as compared to the non smokers. Similar reductions were found in the Nigerian traffic wardens[8] and petrol pump workers[15].The smoker garage workers also showed a significant ($p<0.05$) fall in $FEF_{25-75\%}$ parameter as compared to the non-smokers. Similar effects were seen in other studies [7,11,19] . It is a well documented fact that cigarette smokers show a reduction in FEF $_{25-75\%}$ as one of the earliest changes in lung function.

EFFECT OF DURATION OF EXPOSURE ON PFT's

In our study with increased duration of work exposure there was a significant decline in FVC and $FEV_{1.0}$ of the garage workers **(Table 6)**. Similar effects of automobile exhaust on FVC and $FEV_{1.0}$ have been reported in tunnel and bridge workers, shopkeepers. [11, 20] However, no relation was found between duration of exposure and declining PFT's among Lucknow traffikmen. [14]

In the present study, FEV 1% did not show any significant change with the increased duration of exposure. The proportionate fall in FVC and $FEV_{1.0}$, with FEV 1% remaining within the normal limit is hall mark of restrictive lung disease. This implied that with increased exposure to automobile exhaust there was more likelihood of garage workers developing restrictive pulmonary impairment. Similar results were found in other studies.[17,19,27,28] The significant decline which was noticed in $FEF_{25-75\%}$ with increased duration of exposure of more than 10 years suggested chronic exposure to exhaust emission and fuel vapour as cause of chronic inflammation and early closure of small airways leading to a peripheral airways obstructive defect .Similar effects on $FEF_{25-75\%}$ with increased duration of exposure were found in studies.[7,9,15,19,29] These findings point towards adverse effects of auto exhaust mainly on the lower airways with restrictive patterns of pulmonary disease developing in the garage workers. With increasing duration of exposure to auto exhaust emission, the deterioration in pulmonary functions and higher prevalence of most chronic respiratory symptoms was noticed. With mean duration of exposure more than 15 years, there was significant fall in the parameters like $FEV_{1.0}$ and FVC. The proportionate fall in FVC and FEV with $FEV_{1.0}$ remaining within the normal limit was a feature of restrictive lung disease. There is also deterioration in $FEF_{25-75\%}$, a features of small airways obstruction. Smoker garage workers had higher frequency chronic respiratory symptoms and lung function impairment as compared to non smoker garage workers.

CONCLUSION:

It was found that people who are exposed to auto exhaust emission for more than 15 years are likely to develop mixed type of lung disease (both restrictive and obstructive pattern of respiratory function was evident in these garage workers) and smoking appeared to accelerate the decline in lung function.

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