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# Effect of advancing age on pulmonary functions in petrol pump workers of Cuttack: a cross sectional study

Priyadarshini G[1], Mishra A[2], Mohanty RR[3]

**Correspondence to:**

girijapriyadarshini@gmail.com

[1] ***Dr. Girija Priyadarshini***, MBBS, Post graduate student, Department of Physiology, Sri Ram Chandra Bhanja Medical College, Cuttack, Orissa, India.

[2] ***Dr. Archana Mishra,*** MBBS, MD, Associate Professor.

[3] ***Dr. Rama Raman Mohanty,*** MBBS, MD, Professor.

All authors are affiliated to
Department of Physiology, Sri Ram Chandra Bhanja Medical College, Cuttack, Orissa, India.

***Editors for this Article:***

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## Abstract

### Background

Environmental pollution is a worldwide phenomenon. Petrol pump workers are exposed to toxic substances present in petrol and diesel and also to various air pollutants. Long term exposure of these chemical vapours leads to deleterious effects on respiratory functions that range from mild cough to lung cancer. In the present study an attempt has been made to find out the correlation of advancing age and toxic effects of vapours on respiratory system by comparing pulmonary function tests in petrol pump workers and subjects not exposed to petrol.

### Methods

The study comprised of 60 petrol pump workers in age group 30-60 years working for more than 1 year. 60 healthy age matched male served as controls. Age, smoking habits, duration of exposure and health conditions of each subject were recorded. The pulmonary function was assessed in all subjects by Medspiror having Helios 401 software. The pulmonary function parameters studied were FVC, $FEV_1$, $FEV_1$/FVC ratio, $FEF_{25-75\%}$, PEFR and MVV. The parameters were compared by using Student's t-test, ANOVA and multiple comparison Bonferroni tests.

### Results

A statistically significant decline in $FEV_1$, FVC, PEFR, $FEF_{25-75\%}$ and MVV was observed in petrol pump workers with advancing age. However, decline in $FEV_1$/FVC was significant in elderly age of 50 to 60 years.

### Conclusion

Elder workers were more susceptible to harmful effects of benzene and other gaseous pollutants on pulmonary functions. Early recognition and removal of susceptible workers from work place before chronic impairment develops will prove to be beneficial.

**Key words**
Pulmonary function, petrol and diesel fumes, benzene, air pollution

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## Background

Environmental pollution is a worldwide phenomenon. Developing nations industrialize faster without following proper rules and regulations [1]. Air pollution increases mortality and decrease life expectancy [2]. Asian countries air pollution is alarmingly high because of rapid economic development occurring in the last decade [3, 4]. Some occupation increases these risk factors because of this dust or chemical exposure, which may leads to bronchial carcinoma [5, 6].

A number of literatures showed the prevalence of occupational health hazards is very high among Indians [7, 8]. Petrol pump workers are exposed to toxic chemical substances (benzene, toluene, ethylbenzene, xylene and lead) present in petrol and diesel and also to various air pollutants. These people suffer from multitude of health problems ranging from mild cough to lung cancer [9]. Older individuals are more susceptible to environmental toxic exposure. Antigenic stimuli from environment and ageing associated down regulatory response leads to generate a low grade inflammatory state in the lower region of the respiratory tract. There is increased incidence of chronic obstructive pulmonary disease at the age of 40 years. Air pollution plays a contributory factor [10]. Ageing promotes proteolytic and oxidant mediated damage to the lungs. Protective role of Epithelial lining fluid (ELF) in this context is well documented. Nitrous oxide and particulate matter in presence of ozone plays an active role for antioxidant depletion in ELF. So age plays a vital role for increasing susceptibility of the old persons to toxic substances [11, 12]. Tobacco smoking and environmental particulate matter pollution have measurable effects on respiratory symptoms in elder population [13-15]. A number of studies are available on the toxic effect of vapours in petrol pump workers, but none of them documented age associated changes. So, in the present study an attempt has been made to justify toxic effects of petrol on respiratory system of elderly petrol pump workers by comparing pulmonary function tests with normal subjects.

## Material and Methods

### Study Period

The present cross sectional study was carried out for a period of one year from February 2013 to March 2014.

### Study design and the participants

Experiment was performed in the Post Graduate Department of Physiology, S.C.B Medical College, Cuttack, Orissa.

Subjects were selected from the petrol pumps located in the vicinity of institution and were brought to the laboratory for test. The study group comprised of 60 males in age group of 30-60 years working in petrol pump for more than 1 year. As we had not got any female workers in the petrol pumps, so female gender was not considered during selection of control group. This is a cross-sectional study with a limited sample size so we preferred to work nearby the institution. Another reason was close proximity, helped subjects to come for the clinical examinations and respiratory function tests performed in S.C.B medical College. We had taken a short interview of the subjects, which included their smoking habits, clinical history, duty hours approximately 8 hours per day and duration of the services (>1 year). The control group consisted of 60 height and weight matched males of same age group not exposed to petroleum vapour, from the preclinical and paraclinical departments of S.C.B medical College, Cuttack.

Detailed history was recorded and complete clinical examination was done at the beginning of the experiment. The anthropometric measurements like height and weight of the subject were also measured.

### Experimentation and collection of data

**Recording of PFT:**

The equipment used for PFT was RMS medspiror (Helios 401 Software by Recorders & Medicare Systems (RMS), Chandigarh, Version 0.1, Jan 2004). Subject was asked to relax for 5 minutes, prior to performing the test. All tests were recorded 3 times (sitting posture) and out of them best maneuver was considered.

**FVC test:**

We put a nose clip to the subject and a clean mouth piece was attached to breathing tube. The subject was asked to take a deep maximal inspiration and exhale as rapidly and as completely as possible into mouth piece.

**MVV test:**

MVV was recorded by asking the patient to take deep breaths as rapidly and forcefully as possible for 15 seconds. Following parameters were recorded: Forced vital capacity (FVC), forced expiratory volume in 1st second ($FEV_1$), $FEV_1$/FVC ratio, Forced expiratory flow at 25-75% of the pulmonary volume ($FEF_{25-75\%}$), peak expiratory flow rate (PEFR), maximum voluntary ventilation (MVV).

### Inclusion criteria

Male subjects, age group between 30 -60 years, physically and mentally fit, co-operative and capable of understanding the procedure and willing to participate voluntarily in the study was considered.

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### Exclusion criteria

By personal interview, smokers and tobacco chewers were excluded. Clinical history was taken, where pathophysiological conditions like pulmonary tuberculosis, bronchial asthma, bronchitis, emphysema of lungs, any types of malignancy was not considered for this study. Some other clinical abnormalities of vertebral column and thorax and subjects who had undergone abdominal or chest surgery advised not to participate in our research work.

### Ethical committee approval

Written informed consent from was taken from each subject, and this study was performed according the declaration of Helsinki. Institution ethical committee approved this research work.

### Data management and statistical analysis

All data expressed as mean±SD. Statistical analysis was done using unpaired students t test, one way analysis of variance (ANOVA) and multiple comparison Bonferroni (post hoc) tests. A level of p value <0.05 was used to indicate statistical significance in all analyses. Data analyzed using SPSS version 19.

## Results

Table - 1 expedites age wise comparison of anthropometric parameters between study and control group. There is no significant difference in any of the parameters between different age groups of petrol pump workers and control subjects indicating samples are homogenous in nature.

Table - 2 explains in the study group all pulmonary function parameters decline progressively with advancing age. Significant reduction is seen in $FEV_1$, FVC, $FEV_1$/FVC ratio, FEF25-75% and MVV from 30-60 years. The decrease in pulmonary function parameters except FVC and PEFR is maximum in group III i.e 50-60 years age group as level of significance is highest.

It is revealed in Table - 3, $FEV_1$, FVC, $FEF_{25-75\%}$ and MVV are statistically significant in control group as age advances from 30-60 years. The decrease in all parameters except $FEV_1$/FVC ratio and PEFR is maximum in group III.

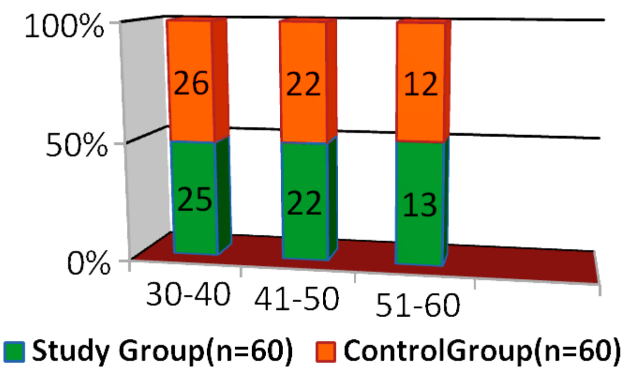


**Figure - 1 shows age wise distribution of study and control group.**

**Table – 2A Comparison of lung function test parameters between different age groups exposed to petroleum vapor (ANOVA) (Mean±SD)**

| | Gr.I 30-40yrs (n=25) | Gr.II 41-50yrs (n=22) | Gr.III 51-60yrs (n=13) | P Value |
|---|---|---|---|---|
| FEV1(L) | 2.54±0.302 | 1.92±0.358 | 1.87±0.354 | 0.000† |
| FVC(L) | 2.83±0.411 | 2.26±0.421 | 2.55±0.472 | 0.002† |
| $FEV_1$/FVC (%) | 90.77±7.51 | 85.71±12.49 | 74.01±11.27 | 0.002† |
| $FEF_{25-75\%}$ (L/sec) | 3.48±0.551 | 2.61±1.229 | 1.59±0.582 | 0.000† |
| PEFR(L/sec) | 4.61±1.283 | 4.28±1.361 | 3.97±1.364 | 0.508x |
| MVV(L/min) | 110.55±19.84 | 93.26±21.84 | 80.25±2.71 | 0.001† |

†P<0.01, statistically significant
xP>0.05, statistically not significant

**Table – 2B Comparison of lung function test parameters between different age groups exposed to petroleum vapor (post hoc)**

| | Gr.I vs Gr.II | Gr.I vs Gr.III | Gr.II vs Gr.III |
|---|---|---|---|
| $FEV_1$(L) | 0.000† | 0.000† | 1x |
| FVC(L) | 0.002† | 0.392x | 0.413x |
| $FEV_1$/FVC (%) | 0.506x | 0.001† | 0.045* |
| $FEF_{25-75\%}$ (L/sec) | 0.021* | 0.000† | 0.031* |
| PEFR(L/sec) | 1x | 0.791x | 1x |
| MVV(L/min) | 0.021* | 0.002† | 0.366x |

†P<0.01, statistically significant
*P<0.05, statistically significant
xP>0.05, statistically not significant

**Table – 1 Anthropometric parameters in Study and control group (Mean±SD)**

| | 30 – 40 Years | | | 41 – 50 Years | | | 51 – 60 Years | | |
|---|---|---|---|---|---|---|---|---|---|
| | Study group (n=25) | Control Group (n=26) | P Value | Study Group (n=22) | Control Group (n=22) | P Value | Study Group (n=13) | Control Group (n=12) | P Value |
| Age(yrs) | 36.44±2.85 | 35.84±3.13 | 0.546x | 46.13±3.06 | 45.33±2.66 | 0.452x | 56.62±2.82 | 55.25±1.49 | 0.567x |
| Height (mt) | 1.66±0.25 | 1.61±0.06 | 0.363x | 1.61±0.05 | 1.63±0.06 | 0.267x | 1.58±0.04 | 1.59±0.04 | 0.651x |
| Weight (Kg) | 58±8.97 | 63±12.55 | 0.174x | 71.21±10.73 | 68.47±11.2 | 0.303x | 56.62±5.93 | 59.42±12.93 | 0.59x |
| BMI (Kg/m2) | 22.36±3.26 | 24.15±4.11 | 0.154x | 24.94±3.87 | 25.75±3.46 | 0.547x | 22.6±2.45 | 23.26±4.335 | 0.717x |

xP>0.05, statistically not significant

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**Table – 3A Lung function test parameters compared in control group (ANOVA)**

| | Gr.I 30-40yrs (n=26) | Gr.II 41-50yrs (n=22) | Gr.III 51-60yrs (n=12) | P Value |
|---|---|---|---|---|
| $FEV_1$(L) | 2.79±0.162 | 2.54±0.238 | 2.36±0.2 | 0.000† |
| FVC(L) | 3.06±0.224 | 2.83±0.38 | 2.56±0.27 | 0.002† |
| $FEV_1$ /FVC (%) | 91.57 ±4.79 | 90.11±6.03 | 92.75±9.69 | 0.625x |
| $FEF_{25-75\%}$ (L/sec) | 3.86± 0.6 | 3.49±0.56 | 2.96±0.51 | 0.004† |
| PEFR(L/sec) | 6.63±1.129 | 6.53±1.12 | 5.77±1.5 | 0.273 |
| MVV(L/min) | 113.16±21.4 | 110.93±25.63 | 90.14±6.33 | 0.048* |

†P<0.01, statistically significant
*P<0.05, statistically significant
xP>0.05, statistically not significant

**Table – 3B Lung function test parameters compared in control group (post hoc)**

| | Gr.I vs Gr.II | Gr.I vs Gr.III | Gr.II vs Gr.III |
|---|---|---|---|
| $FEV_1$(L) | 0.002† | 0.000† | 0.191x |
| FVC(L) | 0.097x | 0.002† | 0.169x |
| $FEV_1$ /FVC (%) | 1x | 1x | 1x |
| $FEF_{25-75\%}$ (L/sec) | 0.239x | 0.003† | 0.142x |
| PEFR(L/sec) | 1x | 0.35x | 0.542x |

†P<0.01, statistically significant
*P<0.05, statistically significant
xP>0.05, statistically not significant

## DISCUSSION

In the present research work, lung function parameters ($FEV_1$, FVC, $FEF_{25-75\%}$ and MVV etc.) were recorded and compared between different age group subjects exposed to vapors in petrol pump and the controls. Apart from that, the intergroup comparison was done to obtain the level of respiratory performances between each age group.

**Ageing and decreased respiratory performances**

We observed significant reduction of FEV1, FVC, $FEF_{25-75\%}$ and MVV with advancing age in both study and control group. This is in accordance with various studies that showed expiratory flow rates and vital capacity decline with advancing age [16, 17].

Experimental evidences supports that ageing causes decreased elastic recoil, stiffness of chest wall, changes in distensibility of lungs which results in static air trapping, increased FRC, a reduction in vital capacity and increased work of breathing. Another important aspect is reduction in supporting tissue around airways leads to collapse of small airways.

Ageing leads to decrease in small airway diameter which may contribute to decreased expiratory flow rate [18].

MVV is influenced by respiratory pump which is at mechanical disadvantage at old age due to reduced diaphragmatic strength, poor cardiac index and altered nutritional status [19, 20].

**Reduced $FEV_1$/FVC ratio in subjects exposed to petroleum vapour**

Decline in $FEV_1$/FVC ratio in study group with advancing age points towards an obstructive pathology. The decline in FEV1, FVC and $FEF_{25-75\%}$ with advancing aged in exposed group as compared to non-exposed may be due to toxic effects of BTEX compound, CDNP and various air pollutants.

These harmful substances may cause bronchial wall thickening, inflammation, fibrosis and terminal bronchiole remodeling as a result of particulate matter deposition. This leads to restrictive pattern of impairment. Our study results corroborates with other workers in the same field [21, 22]. Dissimilar to our research Singhal M and his co workers revealed although there is reduction in FVC and $FEV_1$ in the study group while their ratio did not differ much [23]. A number of other contributory factors are $SO_2$, $NO_2$, PM<2.5µm which has greater chance to reach deeper parts of lung and alters surfactant concentration contributing to early closure of small airways [8].

**Table – 4 Age wise comparison of pulmonary function parameters between study and control group ( Mean±SD)**

| | 30 – 40 Years | | | 41 – 50 Years | | | 51 – 60 Years | | |
|---|---|---|---|---|---|---|---|---|---|
| | Study Group (n=25) | Control Group (n=26) | P Value | Study Group (n=22) | Control Group (n=22) | P Value | Study Group (n=13) | Control Group (n=12) | P Value |
| $FEV_1$(L) | 2.54 ±0.30 | 2.79±0.16 | 0.003† | 1.92±0.36 | 2.54±0.24 | 0.000† | 1.87±0.35 | 2.36±0.2 | 0.007† |
| FVC(L) | 2.82±0.41 | 3.06±0.22 | 0.034* | 2.26±0.42 | 2.83±0.38 | 0.001† | 2.55±0.47 | 2.56±0.27 | 0.926x |
| $FEV_1$ /FVC (%) | 90.77±7.51 | 91.57 ±4.79 | 0.699x | 85.71±12.4 | 90.11±6.03 | 0.23x | 74.00±11.27 | 92.75±9.69 | 0.005† |
| $FEF_{25-75\%}$ (L/sec) | 3.47 ±0.55 | 3.85±0.6 | 0.056x | 2.61±1.23 | 3.49±0.56 | 0.017* | 1.59±0.58 | 2.96±0.51 | 0.000† |
| PEFR(L/sec) | 4.60 ±1.28 | 6.63±1.13 | 0.000† | 4.28 ±1.36 | 6.52±1.12 | 0.000† | 3.97±1.36 | 5.77±1.5 | 0.03* |
| MVV(L/min) | 110.55±19.84 | 113.16±21.4 | 0.704x | 93.26±21.84 | 110.93±25.63 | 0.052* | 80.25 ±2.71 | 90.14±6.33 | 0.001† |

†P<0.01, statistically significant
*P<0.05, statistically significant
xP>0.05, statistically not significant

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**Changes in FEF among the workers**

FEF25-75% is a sensitive indicator of small airway disease where most COPD starts [23]. A very interesting outcome of our research is that, as the age progresses there is significant reduction in the FEF among the study group when compared with control. It supports that in the early stage most of the workers unnoticed, but advancement of age makes them more susceptible, noticeable for the effect of these detrimental vapours [11, 23, 24]. Some studies reported the possible reason for this reduction is loss of bronchiolar attachment as a result of extracellular matrix destruction due to both toxic particle deposition and advancing age may also cause small airway obstruction leading to decreased $FEF_{25-75\%}$ [25, 26].

In our study we also noticed that, petrol pumps were located on busy roads, of the Cuttack city, so there are indeed chance for these workers to expose with other air pollutants like Ozone, Particulate Matter, Carbon Monoxide, Nitrogen Oxides, Sulfur Dioxide and Lead. PEFR indicates large airway obstruction. Significant decrease in PEFR in exposed workers may be due to increased airway resistance in bronchi and large bronchioles. Occupational exposure to gaseous pollutants is major cause of increased airway reactivity i.e. bronchial asthma. At low lung volumes i.e. restrictive disorders expiratory force is less so as PEFR. MVV is considered good guideline of mechanical efficiency of lungs. Its significant decline in 50-60 years age is due to benzene which reduces mechanical properties of breathing that adds to already deteriorating respiratory apparatus [27]. There is lack of information from other investigators regarding lung function abnormalities due to exposure to petrol in elderly people. Hence, a comparative study could not be undertaken and strength and weakness in relation to other studies could not be deciphered. Diesel exhaust particles are very small with diameters of 0.02 nm and 0.2 nm and present in the nuclei or accumulation modes respectively. Although particle size is small, but their larger surface area to mass ratio, enables to carry massive quantity of toxic compounds, such as hydrocarbons and metal particles on their surface [28].

## Conclusion

Thus our study validates toxic effects of petrol and diesel on pulmonary functions of petrol pump workers with advancing age most marked in 50-60 years. With age pattern of impairment changes from restrictive to obstructive. Proper health check up could reveal sensitive workers and they should be removed. Interventional strategies, proper health care policies should be formulated and adopted for the benefit of the workers. Benzene concentration in air emissions should be reduced in the petrol pumps. Ambient air quality guideline for safe standard level must be followed. Frequent health checkups and regular monitoring of pulmonary function among workers would be beneficial in this context. Use of face mask and biodiesel should be promoted. Implementation of Biodiesel in petrol pumps can change the scenario.

## Limitations & future scope of the study

There are some limitations of this study, like ambient air quality data inside and near petrol pumps and level of respirable SPM couldn't be analyzed. Our sample size is also less, so broad spectrum multicentric studies including other districts are strongly recommended.

## Abbreviations

Benzene, toluene, ethylbenzene , xylene (BTEX), chronic obstructive pulmonary disease (COPD), combustion derived nano particles (CDNP), epithelial lining fluid (ELF) forced expiratory flow (FEF), forced expiratory volume in 1st second ($FEV_1$), forced vital capacity (FVC), functional residual capacity (FRC), maximum voluntary ventilation (MVV), peak expiratory flow rate (PEFR), suspended particulate matter (SPM).

## Competing interests

Authors don't have any competing interest.

## Authors' contribution

GP and AM designed the study, performed the experiment, interpreted the data, drafted the manuscript and revised it. RRM critically revised the manuscript. Final manuscript was approved by all authors.

## Authors' information

***Dr. Girija Priyadarshini,*** Post graduate student, Department of Physiology, S.C.B Medical College, Cuttack, Orissa, India.
***Dr. Archana Mishra***, Associate Professor, Department of Physiology, S.C.B Medical College, Cuttack, Orissa, India.
***Dr. Rama Raman Mohanty***, Professor, Department of Physiology, S.C.B Medical College, Cuttack, Orissa, India.

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