Exposure to Vehicular Pollution and Respiratory Impairment of Traffic Policemen in Jalgaon City, India

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Abstract: The ambient air quality monitoring was carried during the May 2003 to April 2004 along the (NH-6) passing through Jalgaon city. The average concentration of SOx 64 µg/m³, NOx 58 µg/m³, particulates (>10 µ) 515 µg/m³ and respirable dust particulates 224 µg/m³ was reported at Prabhat during the study period (May 2003–April 2004). This location represents the major highway crossings (four) in the study area. The present investigations are on the survey of health status and lung function of traffic policemen exposed to the inferior air quality as observed on the highway crossings. The spirometric analysis of traffic policemen shows significant variation in Peak Expiratory Flow Rate (PEFR), Forced Expiratory Volume in one second (FEV₁) and Forced Vital Capacity (FVC). The parameters were significantly affected in the traffic policemen as against the control group of population. It reveals significant respiratory impairment in the traffic policemen due to exposure to vehicular pollution. The study suggest the compulsory use of personal protective equipment (nose mask) by the traffic policemen during duty hours will help for the protection from vehicular pollution. The regular periodic health checkup is required to understand the impact of vehicular pollution on the health of traffic policemen.

Key words: Pulmonary function, PM, SOx, NOx, Traffic-policemen

Introduction

In urban areas mobile or vehicular pollution is predominant and significantly contributes to air quality problems. Road traffic produce volatile organic compounds, suspended particulate matter (SPM), oxides of sulphur (SOx), oxides of nitrogen (NOx), and carbon monoxide (CO), which makes adverse health effects on the exposed population. The particles emitted from the vehicular exhaust of more than 10-micron size are held in upper respiratory tract and particles less than 10-micron size (PM₁₀) accumulates in the lung and produces respiratory abnormalities. Hence, PM₁₀ are of great concern in air pollution studies.

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 death¹,². The major subgroups of the population that appear to be most sensitive to the effects of particulate matter include individuals with chronic obstructive pulmonary, cardiovascular disease, influenza and asthmatics³,⁴.

The prevalence of obstructive, restrictive and mixed type of functional impairment of the lung was found to have direct relationship with the dust concentration and duration of exposure⁵,⁶. Prolonged exposure to dust can result in chronic bronchial problems⁷–¹¹. Investigations of the respiratory health effects from vehicular pollution exposures are necessary in order to predict the risk factors that may cause an asthmatic response¹²–¹⁴. Several research works has confirmed the effects of air pollutants on respiratory function of human being. This study shows a link between exposure to vehicular exhaust and pulmonary function. Studies have shown reversible decrement in pulmonary function in the
population exposed to traffic pollution\textsuperscript{15}). The continuous vehicular exhaust inhalation can lead to the symptoms of lower respiratory tract such as cough, shortness of breath and pain with inspiration\textsuperscript{16, 17}). Age induced asthma was also reported in the population by USNRC 1981\textsuperscript{18}, Williams 1986\textsuperscript{19} and WHO 1997\textsuperscript{20}). Cotes J.E.\textsuperscript{21} reported decline in the perfusion of lung by increasing age. Prominent effect was observed above 60 yr of the age, considered as age-induced asthma. Sengupta et al. (1974)\textsuperscript{22} has reported the age-induced asthma in the Indian population. The present study is restricted to the policemen in the age group of 20–55 yr.

Jalgaon City is the trade and commercial center of North Maharashtra Region, India. City includes all type of population groups. The population of Jalgaon City had grown up by 23% during 1981–91 and by 19% during 1991–2001. Current population of the City is standing at 4 lacks. With the population, vehicular number is also increasing in the city. The data shows that nearly 400 new vehicles are registered every day at Jalgaon Road Transport Office. There are 60 traffic policemen to control the traffic on the roads. National Highway No. 6 is passing through the city and the study includes 07 road crossings on the way. The duty hours of the traffic policemen are 9 am to 9 pm including recess. It means for at least 10 h the traffic policemen working at road crossings receive the heavy dose of vehicular pollution. The average vehicular density on highway is 17,000 vehicles/day [8,000 (2+3 wheelers), 3,000 light vehicles and 6,000 heavy vehicles]. Vehicle population data of Jalgaon district shows that there is a continuous increase of vehicles since 1998 to 2002 (Fig. 1). Higher incomes, mobility and rapid expansion of the city in the last five years have increased the demand of motorized transport, resulting in the disproportional higher number of vehicles in the urban center. Irrational distance between homes and places of work, greater incentives for private transport and inadequate and poor quality public transport has further aggravated the problem in the city. In the survey it was observed that the policemen were never used personal protective equipment for protection from the dust prevailing at workplace environment.

The national highway (NH-6) passing through the city is characterized by a continuous flow of heavy-duty trucks and containers. Among the vehicular flow the diesel vehicles are in higher population. Smoke is one of the major outcomes of diesel burning. Nearly all diesel smoke particles fall into the fine particle size. Small size and large number of particles offer greater surface area that allows toxic organic compounds to get adsorbed easily. Fine smoke particles can go deep into the lower respiratory tract and damages the lung tissue.

Studies have proved that diesel vehicles emit fine and ultra fine particles in very large quantities\textsuperscript{22}). A questionnaire was used to generate information on self-reported health problems in the traffic policemen.

**Materials and Methodology**

The health impacts of exposure to air pollutants can be estimated by studying the workplace environment, risk assessment of exposure and pulmonary function test.

**Study population**

The study comprises 60 traffic policemen in Jalgaon city having no smoking habit. Fifty healthy young adult natives of Jalgaon city are served as a control group. All the control samples are taken from middle class income group whose lifestyle is nearly similar to that of traffic policemen. The control samples are either working in the co-operative banks, private institutions and offices who are less exposed to the traffic pollution.

**Workplace environment of traffic policemen**

Total 15 Km road length was selected for the study on the National Highway which is passing through the City. The ambient air monitoring was conducted during May 2003 to April 2004 at three sampling locations in the study area. The air monitoring was conducted at the rate of three samples per season at each location. The monitoring was carried out by High Volume Sampler (APM-460, Envirotech Instruments Pvt. Ltd, India). Sulphur dioxide (SO\textsubscript{x}), was analyzed by West and Gaeke method (1956)\textsuperscript{23} and NO\textsubscript{x}, was analyzed by Jacob-Hochheiser method (1958)\textsuperscript{24}. The respirable particulates (PM\textsubscript{10}) were collected on glass fiber filter and suspended particulate matter was collected by gravity settling method.
Air Quality Index

The ambient air quality data was processed for air quality index (AQI). AQI was calculated for premonsoon, post monsoon, winter and summer seasons. The average of three samples per season was considered for calculation of AQI. Air Quality Index was estimated by using the results of (SOx, NOx, PM$_{10}$ and SPM) air analysis. The classification of air quality index is carried out according to National Ambient Air Quality Standard (NAAQS, 1994).

Pulmonary Function Test

The traffic policemen and control samples were subjected to Pulmonary Function Test. Before the test age, height and weight of the subjects were entered in the spirometer (Medspior, Recorder and Medicare Systems, India). The spirometer gives two values one is expected and other is actual. The Medspior Software using a set of prediction equations for the adults calculates the expected values.

The equations for prediction are as follows:

\[
\begin{align*}
FVC (L) & = 0.050H - 0.014A - 4.49 \\
FEV_1 (L) & = 0.040H - 0.021A - 3.13 \\
PEFR (L/Sec) & = 0.071H - 0.035A - 1.82
\end{align*}
\]

Where,

- \(H\): is height in cm and
- \(A\): is age in years.
- FVC: Forced Vital Capacity- is the maximum amount of air that can be exhaled following a maximal inspiratory effort.
- FEV$_1$: Forced Expiratory Volume in One second- is the volume of air exhaled in a one second during a forced vital capacity effort
- PEFR: Peak Expiratory Flow Rate- it is the maximum amount of air exhaled with forced effort during the FVC.

The pulmonary function test of control and target groups were conducted during the winter season. This season is characterized by worst meteorological conditions and hence accumulation and increase in levels of air pollution. The test were conducted in the morning hours and ensured that the subject was not exposed to air pollution at least for 12 h before the test.

The actual values (FVC, FEV$_1$ and PEFR) are based on maximal inspiration and expiration of the subjects. The pulmonary function test was conducted by sitting the subject comfortably in the chair. Regular sterilization of the mouthpieces was done before the use. The subjects were asked to take maximum inspiration followed by maximal exhalation. Three such tests were performed and subjects were coached to improve the efforts. The best of the three performances of FEV$_1$, FVC and PEFR was taken into account.

Statistical analysis

The data was processed for mean, standard deviation, one-way ANOVA. It comprises recording of Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV$_1$) and Peak Expiratory Flow Rate (PEFR).

Risk assessment

The data on the health status of the study group was collected by standard questionnaire. The Respirator Medical Evaluation Questionnaire (OSHA, 1998) was used for collection of the data. The questionnaire was translated in the local language. The symptoms viz. frequent coughing, shortness of breath and irritation in respiratory tract were considered for odd ratio analysis. The risk was calculated between the traffic policemen and control group having different exposure to risk factor. Analysis of odd ratio was conducted by setting up a simple $2 \times 2$ matrix shown in the Fig. 2.

Odd ratio is defined as the cross product of the entries in the matrix:

\[
\text{Odd ratio} = \frac{ad}{bc}
\]

The odd ratio above 1.0 suggests a relationship between exposure and risk.

Results and Discussion

Automobiles are ‘necessary evils’ on one hand they have made living easy and convenient, but on the other hand they have also made human life more complicated and vulnerable to both toxic emissions and increased risk of accidents. Urban peoples are the most affected and among the worst sufferers are traffic policemen who are particularly close to the automobile exhaust. Studies made in India indicate that
The data on seasonal air monitoring was presented in Table 1. It was observed that during the winter season the concentration of oxides of sulfur and nitrogen are very high. The average concentration of SO$_x$ and NO$_x$ was in the range of 94 to 139 $\mu$g/m$^3$ and 83 to 121 $\mu$g/m$^3$ respectively in the study area during this season. The winter season is characterized by low wind velocity (average wind velocity 5.28 Km/h) and hence the higher levels of gaseous pollutants are observed during this period in the sampling area. It was also observed that particulates concentration during summer and premonsoon season was very high. In summer season the SPM varied between 597 to 857 $\mu$g/m$^3$. Premonsoon season was characterized by higher levels of SPM varied between 437 to 957 $\mu$g/m$^3$. The wind flows speedily (average wind velocity 12.45 Km/h) during summer season of the year. As a result the maximum air borne dust increases in the ambient air. In post monsoon season due to scrubbing action of rainwater and high humidity the concentration of pollutants lower down.

Table 2 reveals the air quality at different road crossing along the National Highway. The Air Quality Index shows moderately polluted air quality at sampling locations throughout the year (May 2003–April 2004). In winter season the air quality varies from very poor to critical. The exposure of human being to such a air quality will be hazardous and may creates serious respiratory problems. In post-monsoon season the air quality index was much lower due to scrubbing of pollution.

Table 3 shows average age, height and weight of the traffic policemen and control group. The service of the 60 policemen was noted to know the duration of exposure. The analysis of questionnaire shows that 40% of the traffic policemen are suffering from frequent coughing, 10% from shortness of breath and 29% from irritation in respiratory tract. The data on the length of service shows that 67% of the traffic policemen are in traffic service for more than 10 yr. The long-term exposure to pollution may be the reason for respiratory symptoms among the traffic policemen. In comparison of traffic policemen the cases were less in the
control group. The respiratory symptoms observed in the control group may be due to exposure to the anthropogenic factors of urban air pollution. In control group only 18% were suffered from frequent coughing, 08% shortness of breath and 05% were suffered from irritation in respiratory tract.

The data on odd ratio (Table 4) shows the higher risk for traffic policemen exposed to the ambient air prevailing at the workplace environment. The odd ratio for the symptoms studied (frequent coughing, shortness of breath and irritation to respiratory tract) was above 1. The odd ratio values for frequent coughing, shortness of breath and respiratory tract are 2.96, 1.22 and 7.5 respectively at 95% class interval level. The values shows significant prevalence of the symptoms studied in the traffic policemen than the control group. There is significant excess risk of respiratory problems for the traffic policemen exposed to highway traffic pollution.

Pulmonary Function Test is the tool of evaluating the patient’s respiratory status. This includes managing patients with pulmonary disease and highlighting pulmonary disability. Table 5 displays the pulmonary function test in traffic policemen and control group. One way-ANOVA was applied to the pulmonary function test of the target groups. The test was performed for comparison of expected and observed values against their individual pulmonary function test in target groups. It was observed that FVC in traffic policemen was (3.03 L) less than the expected (3.70 L) value. Forced Vital Capacity is the maximal amount of air that can be exhaled following a maximal inspiratory effort. The average FVC in traffic policemen was 82% of the expected value. In control group the FVC observed was (3.18 L) which was close to the expected FVC (3.19 L). The average FVC of control group was 99% of the expected value.

Peak Expiratory Flow Rate (PEFR) is the best test of

### Table 3. General characteristics and symptoms of respiratory diseases in the target groups (n=60)

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Parameter</th>
<th>Result</th>
<th>T. Policemen</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Age (yr)</td>
<td>40 ± 15 (24–55)</td>
<td>41 ± 12 (25–55)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Height (cm)</td>
<td>170 ± 4.92 (165–186)</td>
<td>173 ± 7 (165–184)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Weight (Kg)</td>
<td>71 ± 12.2 (50–106)</td>
<td>68 ± 8 (55–103)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Duration of exposure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt; 10 yr</td>
<td>66.6%</td>
<td>N.A.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 10 yr</td>
<td>33.3%</td>
<td>N.A.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Symptoms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Frequent coughing</td>
<td>40%*</td>
<td>18%*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shortness of breath</td>
<td>10%*</td>
<td>8%*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Irritation in respiratory tact</td>
<td>29%*</td>
<td>5%*</td>
<td></td>
</tr>
</tbody>
</table>

*Two-way ANOVA p<0.17 test was performed for comparison of symptoms in traffic policemen and control group, where F values in ANOVA are not significant at 0.05. N.A.: Not Applicable. The values are mean ± SD of 60 samples. Values in parenthesis show range of parameter.

### Table 4. Comparison of risk of the respiratory symptoms among traffic policemen (exposed) and control (non exposed) groups (n=60)

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Symptoms</th>
<th>Samples</th>
<th>Prevalence of symptoms</th>
<th>Odd ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Frequent coughing</td>
<td>T. Police</td>
<td>24</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Control</td>
<td>11</td>
<td>49</td>
</tr>
<tr>
<td>2</td>
<td>Shortness of breathe</td>
<td>T. Police</td>
<td>06</td>
<td>54</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Control</td>
<td>05</td>
<td>55</td>
</tr>
<tr>
<td>3</td>
<td>Irritation in respiratory tract</td>
<td>T. Police</td>
<td>17</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Control</td>
<td>03</td>
<td>57</td>
</tr>
</tbody>
</table>

*All the values are significant at 95% (0.05) CI.
expiratory effort. The PEFR was worst affected in traffic policemen. It was 66% of the expected value; PEFR observed was 6.05 L/s, which is less than expected 9.21 L/s. In control group the observed PEFR was 5.54 L/s which was nearer to the expected 6.11 L/s, means it was 92% of the expected value in control group.

FEV1 is the volume of air exhaled in a one second during a forced vital capacity effort. The observed FEV1 in traffic policemen was 2.27 L, and in control group it was 2.81 L. The FEV1 in traffic policemen was 73% of the expected value and in control group it was 118% of the expected value. The overall difference (p) is based on one way ANOVA and the F values in ANOVA are significant, this supports that our assumptions is correct, that traffic policemen have more respiratory impairment as compare to control group. The significant difference is at 95% class interval.

Conclusion

The results of this study indicate reduction in the lung function efficiency of the traffic policemen exposed to vehicular pollution. Similar observations were reported by Gupta et al.32 in the rubber factory workers exposed to particulates prevailing at work place environment. The Forced Vital Capacity (FVC) was 82% of the expected in traffic policemen, while the control group shows 99% efficiency. Though the Forced Vital Capacity (FVC) of traffic policemen was less than the control group, it was not much affected like FEV1 and PEFR. The Forced Expiratory Volume in one second (FEV1) of traffic policemen was affected severely. It shows 0.81 L difference in the expected and observed FEV1 of the subject. This confirms the definite acute effect on forced expiratory volume (FEV1) in the traffic policemen33).

The reduced Peak Expiratory Flow Rate (PEFR) is 66% is the symptom of asthma. The significant reduction in PEFR indicates the warning symptoms of asthma among traffic policemen. Jeelani et al. (1992)27 reported reduced PEFR in the Kashmiri population than healthy western population due to anthropogenic, environmental, genetic and socioeconomic factors. This study concludes that the traffic policemen are highly vulnerable for respiratory impairment due to vehicular exhaust at workplace environment. A large number of epidemiological studies have shown that long-term exposure to the particulates is associated with adverse effect on health34). The strategies (use of mask, regular health checkup and awareness on health impacts of pollution) need to be adopted for protection of traffic policemen working on the heavy traffic roads.

Acknowledgement

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