The Influence of Workplace Environment on Lung Function of Flour Mill Workers in Jalgaon Urban Center

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Abstract: The Influence of Workplace Environment on Lung Function of Flour Mill Workers in Jalgaon Urban Center: Nilesh D. WAGH, et al. School of Environmental Sciences, North Maharashtra University, India—The workplace environment affects the health of workers. Unhygienic conditions are observed in the workplace environment of flour mills as fine organic flour dust gets airborne in the indoor environment of the flour mills. The present work was undertaken to study the health problems related to the workplace environment of flour mill workers. The results show that flour mill workers are receiving a heavy dose (average exposure concentration, 624 µg/m³) of flour dust. To determine the impact of flour dust on the lung function of the workers spirometric analysis was conducted. Significant declines in forced vital capacity (FVC), peak expiratory flow rate (PEFR) and forced expiratory volume in one second (FEV₁) were observed in the flour mill workers as compared to expected values. This study reveals reduced lung efficiency of flour mill workers due to excessive exposure to fine organic dust prevalent in the workplace environment. The impairment in lung efficiency was increased with duration of exposure in the flour mill workers. The analysis of questionnaires used to generate information on self-reported problems reveals that most of the workers were suffering from asthma and respiratory problems. Furthermore, the data shows that 42% of the flour mill workers were having shortness of breath problems, 34% of workers were having frequent coughing, and 19% workers were having respiratory tract irritation. We recommend the compulsory use of personal protective equipment (nose mask) by flour mill workers during working hours. This would help to protect the workers health from the flour dust prevalent in the workplace environment. A regular periodic examination is necessary to measure the impact of particulate matter on the health of the flour mill workers.

Key words: Dust dose, Flour dust PEFR, FEV₁, FVC

Indoor air pollution is a major problem in developing countries, and is increasing more and more due to rapid industrialization and ineffective pollution control measures. It has increased due to lack of public awareness of the impact of indoor air pollutants on human health. Flour mills produce a large amount of flour dust. On average flour mill workers are exposed to the workplace environment for 8–10 h a day and there are no provisions for minimization of the dust produced in the flour mills in India. Poor ventilation is a basic problem in flour mills throughout the country. Flour dust accumulates in the workplace environment because of poor ventilation, hence workers get exposed to excessive amounts of flour dust. Long-term continuous exposure of workers to fine dust leads to pulmonary and respiratory diseases.

The respiratory health effects documented in workers exposed to a variety of dusts include effects on breathing and respiratory symptoms, aggravation of existing respiratory and cardiovascular diseases, alteration of the body defense system against foreign materials, damage to lung tissue and premature death¹. The major subgroups of the population that appear to be most sensitive to the effects of particulate matter include individuals with chronic obstructive pulmonary diseases, cardiovascular disease, influenza and asthma²,³.

Prolonged exposure to dust can result in chronic lung problems⁴–⁸. Investigations of the respiratory health effects from flour dust exposures are necessary in order to predict the risk factors that may cause an asthmatic response⁹–¹¹. Sultan A Meo¹² has confirmed that the long-term exposure of human beings to flour dust may cause acute or chronic respiratory disease. Continuous flour dust inhalation can lead to symptoms of lower respiratory tract inhalation such as cough, shortness of breath and
pain with inspiration\(^{13,14}\). Asthma in the higher ages is due to aging rather than the housing conditions\(^{15}\). Sengupta et al.\(^{16}\) have reported on age induced asthma in the Indian population. The present study was restricted to flour mill workers in the age group of 19–55 yr.

Jalgaon City is a rapidly developing urban center in North Maharashtra, India. Migration of people from nearby villages and towns into the city is continuously increasing. Currently, Jalgaon City has a population of 400,000. The increase in the population of the city was 19\% during 1981–1990, and 23\% during 1991–2000. The number of flour mills has increased with the increase of the population in the city. Presently 72 flour mills are registered in Jalgaon urban center. Unhygienic conditions prevail in almost all of the flour mills in the area. Flour mill workers are one of the groups most affected by indoor air pollution in the workplace. The flour mill workers in this study have been continuously exposed to flour mill dust over the last 10–20 yr. During the study it was observed that these workers were not using any personal protective equipment for their protection from the dust in the workplace environment.

**Material and Methods**

**Study population**

The campaign was conducted by the authors to create awareness of the hazard of flour dust and its impacts on human health. This resulted in a great response by flour mill workers for the spirometric study. The study subjects comprised 59 flour mill workers in Jalgaon City who were non-smokers, and 54 healthy young adult natives of Jalgaon city served as a control group. All the control samples were non-smokers and had no history of respiratory disease. It was confirmed that none of the subjects had respiratory tract symptoms such as cold or cough during the spirometric testing.

**Workplace environment**

The work was carried out in the winter season (Dec 2003–Feb 2004). The humidity of the workplace environment varied from 60–70\%, while the temperature was in the range of 25–30°C. The area of the flour mill and numbers of working units were noted during sampling.

**Dust exposure monitoring**

The exposure of workers to flour dust was measured by a portable personal dust sampler over an 8-h period. The sampling unit contained an air pump powered by an internally sealed lead-acid gel battery. Air was drawn at a flow rate of between 0.5 to 3.5 liters per minute, and the dust-sampling unit was attached to the body of the flour mill worker for 8 h per day. The dust (PM\(_{10}\)) was collected by filtration of air through a glass fiber filter (25 mm diameter). The samples collected were measured by the gravimetric method and expressed as dust in \(\mu g/m^3\).

**Pulmonary function test**

The flour mill workers and controls were given a pulmonary function test. Before the test, age, height and weight of the subjects were entered in the spirometer (Medispiror, Recorder and Medicare Systems, India). The spirometer gives two values: one is the expected value and the other is the actual value. The expected values are based on the height, age and weight of the subjects\(^{17}\). Medispiror software using a set of prediction equations calculates the expected values for the adults.

The equations for prediction were as follows:

\[
FVC (L)=0.050H–0.014A–4.49
\]

\[
FEV\textsubscript{1} (L)=0.040H–0.021A–3.13
\]

\[
PEFR (L /Sec)=0.071H–0.035A–1.82
\]

Where,

- \(H\): is Height in cm
- \(A\): is Age in years.

- \(FVC\): Forced Vital Capacity- is the maximum amount of air that can be exhaled following a maximal inspiratory effort.
- \(FEV\textsubscript{1}\): Forced Expiratory Volume in one second- is the volume of air exhaled in one second during a forced vital capacity effort
- \(PEFR\): Peak Expiratory Flow Rate- is the maximum amount of air exhaled with forced effort during the FVC.

The actual values (FVC, FEV\(_1\), and PEFR) are based on the maximal inspiration and expiration of the subjects. The pulmonary function test was conducted by sitting the subject comfortably in a chair. Sterilization of the mouthpiece was done before use. The subjects were asked to perform maximum inspiration followed by maximal exhalation. Three tests were performed and the subjects were assisted to improve their efforts. The best of the three performances of FVC, FEV\(_1\), and PEFR were taken\(^{18}\). The results of spirometry were assessed according to the criteria given in the manual of the Medispiror.

**Statistical analysis**

The data of forced vital capacity (FVC), forced expiratory volume in one second (FEV\(_1\)), and peak expiratory flow rate (PEFR) was processed for mean, standard deviation, and one-way ANOVA\(^{19}\).

**Risk assessment**

The data on the health status of the study group was collected by a standard questionnaire. The Respirator Medical Evaluation Questionnaire\(^{20}\) was used for collection of the data. The questionnaire was translated into the local language. The symptoms, frequent coughing, shortness of breath and irritation in the
respiratory tract were recorded for the risk assessment. The risk was calculated between the flour mill workers and control group having different exposures to risk factors. The relative and attributable risks were calculated by setting up a $2 \times 2$ matrix such that the rows divide the population according to those who had exposure (flour mill workers) and those who did not have exposure (control) to the risk factor. The columns are based on the number of individuals who had the symptoms being studied and those who did not in both the target groups\(^{21}\).

**Results and Discussion**

Among the people of India unawareness of occupational health hazards and mortality are reported to be unusually high. Though the developed countries are very careful about occupational health, it is quite neglected in developing countries like India. During the study it was observed that the flour mill workers were not taking any precautionary measures to prevent flour dust exposure during working hours.

**Workplace environment**

Table 1 shows the background characteristics of the workplace environment in the flour mills. The workplace of flour mills is congested and the area varied from 100 to 400 sq. ft. It was noted that 10 horsepower grinding machines are used in the largest flour mills. The average temperature and humidity of the workplace environment during the study period was 29°C and 70%, respectively. The workplace air monitoring in the flour mill shows a high concentration of flour dust. The dust concentration ranged between 430 and 814 $\mu$g/m\(^3\) with an average of 624 $\mu$g/m\(^3\).

During the study it was observed that the flour mill workers are working in very small spaces throughout the day. The standing positions of these workers are very close to the grinding machines. As a result they are continuously exposed to heavy concentration of flour dust. In addition no exhaust system was observed in any flour mill.

**Respiratory symptoms**

The physical parameters of the subjects, i.e. age, height and weight, were considered for the spirometric test (Table 2). The data on the health status of the study group was generated by a standard questionnaire which was translated into the local language. The data reveals that a large number of flour mill workers had problems of shortness of breath, frequent coughing and respiratory tract irritation. Few subjects reported these problems in the control group. These samples were rejected from further study.

The control subjects were less exposed to any type of dust than the flour mill workers who were continuously exposed to the flour dust during working hours. Respiratory disorders were reported by a high number of flour mill workers, as dust particles easily enter the respiratory tract of an exposed person. These particles attach to the inner wall of the respiratory tract and disturb the process of inhalation and exhalation of air. The inner cell wall of the respiratory tract does not accept the foreign particles (flour dust), causing slight irritation in the respiratory tract which is the primary symptom of respiratory disorder.

**Pulmonary function status**

The data of the pulmonary function test show declines in the FVC, FEV\(_1\) and PEFR indices of the flour mill workers as compared to the control group (Table 3). In the control group the observed values of these indices were close to the expected values. FVC (77%) and FEV\(_1\)
(78%) were the most affected parameters, followed by PEFR (79%) in the flour mill workers. A significant decrease ($p<0.05$) was observed in the lung function test of the flour mill workers in comparison to the control subjects.

Forced vital capacity (FVC) and forced expiratory volume in one second (FEV$_1$) are the most important parameters of the spirometric study. In flour mill workers the FVC was less than that of the control subjects. This fall in FVC and FEV$_1$ among the flour mill workers may be due to the accumulation of flour dust particles in the lung airways. Such an accumulation reduces the force which can be applied by the subject during the exhalation and inhalation effort.

The flour mill workers were categorized into four groups as per the duration of their exposure to the flour mill dust. During the survey it was observed that 15 workers had been working for less than 3 yr, 12 workers had been working from 3 to 6 yr, 12 workers had been working from 6 to 9 yr and 20 workers had been working for more than 9 yr in the flour mill. Table 4 shows the decline in the lung parameters with increasing duration of exposure to flour dust among the flour mill workers. A similar reduction in the lung parameters with increasing exposure period has previously been reported in flour mill workers$^{20}$. Thomas and Zelikoff, 1999 also reported a decrease in lung function efficiency with increasing exposure period in flour mill workers$^{22}$. Multiple comparison tests were applied to the different age groups (Table 4). The $F$ test was performed for multiple comparisons of selected variables for significance of difference of age groups where $F$ values in one-way ANOVA are significant. The significant difference is at $p<0.05$ by multiple comparison test.

### Table 3. Pulmonary function test of flour mill workers and control subjects

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>PFT</th>
<th>Flour mill workers (n=59)</th>
<th>Control (n=54)</th>
<th>$p$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Expected</td>
<td>Observed</td>
<td>%</td>
<td>Expected</td>
</tr>
<tr>
<td>1</td>
<td>FVC (L)</td>
<td>2.7 ± 0.26</td>
<td>2.1 ± 0.41</td>
<td>77</td>
</tr>
<tr>
<td>2</td>
<td>FEV$_1$(L)</td>
<td>2.4 ± 0.11</td>
<td>1.9 ± 0.22</td>
<td>78</td>
</tr>
<tr>
<td>3</td>
<td>PEFR (L/S)</td>
<td>7.5 ± 0.15</td>
<td>5.9 ± 0.77</td>
<td>79</td>
</tr>
</tbody>
</table>

Overall difference is based on one-way ANOVA $p<0.0001$. Test was performed for comparison of expected and observed values against their individual pulmonary function test in flour mill workers and control group, where $F$ values in ANOVA are significant. Significant difference at $p<0.05$ by multiple comparison tests.

### Table 4. Pulmonary function test of flour mill workers according to duration of exposure to workplace environment

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>PFT</th>
<th>Duration of exposure (years)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Expected</td>
<td>Observed</td>
<td>%</td>
</tr>
<tr>
<td>1</td>
<td>FVC (L)</td>
<td>&lt; 3 (n=15)</td>
<td>3.1 ± 0.31</td>
</tr>
<tr>
<td>2</td>
<td>FEV$_1$(L)</td>
<td>&gt; 3 to 6 (n=12)</td>
<td>2.6 ± 0.42</td>
</tr>
<tr>
<td>3</td>
<td>PEFR (L/S)</td>
<td>&gt; 6 to 9 (n=12)</td>
<td>7.7 ± 1.21</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt; 9 (n=20)</td>
<td>7.4 ± 0.77</td>
</tr>
</tbody>
</table>

The values are mean ± SD of all samples in a specific exposure period. $^*$F test were performed for multiple comparison of selected variables for significance of difference of age groups where $F$ values in one-way ANOVA are significant. The significant difference is at $p<0.05$ by multiple comparison test.
Hence, the attributable risk for these symptoms of asthma is also more. Attributable risk is the difference between the odds of having the disease with exposure and odds of having the disease without exposure. The attributable risk suggests the relationship between exposure and risk. In the present study the attributable risks are 0.20, 0.24 and 0.11 for frequent coughing, shortness of breath and irritation of the respiratory tract, respectively. The values of relative and attributable risks show that the flour mill workers have a high risk of exposure to the flour dust.

**Ventilatory impairment**

The ventilatory impairment of flour mill workers was categorized on the basis of air flow obstruction (FVC), restrictive defect (FEV₁) and expiratory flow rate (PEFR). The results of the categorization of (Table 6) show that 32% of flour mill workers have normal (healthy) expiratory flow rate, 45% of the flour mill workers have moderate expiratory flow rate with chances of possible respiratory defect, and 23% have severe respiratory defect (asthmatic). Reduced mild restrictive defect and airflow obstruction were observed in 23% and 29% of the flour mill workers, respectively.

During the study it was observed that a large number of flour mill workers suffered from the problems of restrictive defect and air flow obstruction. The decrease in peak expiratory flow rate was also in the severe to moderate range. This indicates reduction in the pulmonary function efficiency among the flour mill workers.

**Conclusion**

Most flour mill workers are unaware of the effects of exposure to flour dust. Unhealthy conditions at the workplace environment were observed in the flour mill during the survey. These conditions affect the health of the exposed workers. A significant reduction in the lung capacity was observed with increasing exposure duration among the flour mill workers. Forced vital capacity (FVC) and forced expiratory volume in one second (FEV₁) of the workers showed severe to moderate chronic obstructive pulmonary disease. Award et al. (1986)²³ reported a drop in FVC and FEV₁ in workers exposed to flour dust. Schwartz et al. (1995)²⁴ also reported similar effects on these parameters in grain mill workers. In the control group, FVC and FEV₁ were close to the expected figures. This shows better lung efficiency in the unexposed population. The situation of peak expiratory flow rate (PEFR) among the flour mill workers was alarming; a significant reduction in PEFR rate was found in the flour mill workers.

This study concludes that flour mill workers are vulnerable to respiratory impairment due to flour dust exposure in the workplace environment. A number of epidemiological studies have shown that day to day exposure to flour particles is associated with adverse effects on health²⁵. We recommend that flour mill workers use masks during working hours. We also recommend that all flour mills should introduce dust exhaust systems into the workplace.

**References**

2) Balmes J: The role of ozone exposure in the

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**Table 5. Risk assessment of flour mill workers exposure to workplace environment**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Symptoms</th>
<th>Relative risk*</th>
<th>Attributable risk**</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Frequent coughing</td>
<td>2.3</td>
<td>0.20</td>
</tr>
<tr>
<td>2</td>
<td>Shortness of breath</td>
<td>3.6</td>
<td>0.24</td>
</tr>
<tr>
<td>3</td>
<td>Irritation in respiratory tract</td>
<td>3.0</td>
<td>0.11</td>
</tr>
</tbody>
</table>

*Relative risk above 1.0 indicates an association between exposure and risk.
**An attributable risk of 0.0 suggest no relationship and above it strong relationship.

**Table 6. Ventilatory impairment in flour mill workers**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Lung status</th>
<th>Flour mill workers (n=59)</th>
<th>Control (n=54)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Air flow obstruction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal (FVC&gt;80%)</td>
<td>60.00%</td>
<td>84.0%</td>
<td></td>
</tr>
<tr>
<td>Mild (FVC 60–80%)</td>
<td>32.00%</td>
<td>15.0%</td>
<td></td>
</tr>
<tr>
<td>Moderate (FVC 40–60%)</td>
<td>8.00%</td>
<td>01.0%</td>
<td></td>
</tr>
<tr>
<td>Severe (FVC&lt;40%)</td>
<td>—</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Restrictive defect</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal (FEV₁&gt;80%) restrictive</td>
<td>57.00%</td>
<td>80.0%</td>
<td></td>
</tr>
<tr>
<td>Mild (FEV₁ 60–80%)</td>
<td>23.00%</td>
<td>20.0%</td>
<td></td>
</tr>
<tr>
<td>Moderate (FEV₁ 40–60%)</td>
<td>20.00%</td>
<td>00.0</td>
<td></td>
</tr>
<tr>
<td>Severe (FEV₁&lt;40%)</td>
<td>—</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Expiratory flow rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal (Healthy) (PEFR&gt;80%)</td>
<td>32.00%</td>
<td>83.00%</td>
<td></td>
</tr>
<tr>
<td>Moderate flow rate (PEFR 50–80%)</td>
<td>45.00%</td>
<td>16.00%</td>
<td></td>
</tr>
<tr>
<td>Respiratory defect (PEFR&lt;50%)</td>
<td>23.00%</td>
<td>00.00%</td>
<td></td>
</tr>
</tbody>
</table>
4) Taggart SC: Asthmatic bronchial hyper responsiveness varies with ambient levels of summertime air pollution. Eur Respir J 9, 1146–1154 (1996)
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