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# Health Risks and Dust Exposure among Flour Mill Workers in Eastern India: A Comprehensive Study

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**Abstract**

Flour milling, a prevalent agricultural industry in semi-urban and urban areas of India, involves grinding whole wheat to produce flour. However, this indoor occupation exposes workers to hazardous flour dust for prolonged periods without adequate ventilation. To investigate the health implications, a study was conducted on 142 flour mill workers in and around Bhubaneswar, Odisha. The findings revealed significant health issues, including respiratory problems (20%), eye irritation (8.6%), headache (11.4%), and shortness of breath (31.4%) among workers. Alarming levels of $PM_{2.5}$ (330–385 µg $m^{-3}$) and $PM_{10}$ (420–470 µg $m^{-3}$) dust particles were recorded. Notably, workers with over 10-15 years of experience displayed reduced pulmonary function, with a decline in force vital capacity (FVC) and forced expiratory volume in one second ($FEV_1$). To mitigate these risks, the study recommends implementing personal protective equipment, improved ventilation, and regular medical care for flour mill workers.

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## Introduction

Wheat milling is the process of grinding whole wheat grains to produce flour, which is essential for home baking and forms the basis of most commercial baked goods. Unlike other grains, wheat has a high enough gluten content to make a standard loaf of bread without requiring the addition of other grains. In India, agriculture and its associated sectors are often seen as forced professions rather than preferred ones, leading to labour migration from rural to urban areas for other job opportunities.[1] Low profitability and hazardous operations are the two main reasons behind the declining interest in agriculture. One of the many hazardous operations in agriculture and its allied sectors is working in a dusty environment, which has adverse effects on respiratory health.

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Workers in flour mills face an increased risk of respiratory issues and diminished lung capacity because of their exposure to dust in the workplace. The workplace atmosphere significantly impacts worker health. Flour mills often have unhygienic conditions, with fine dust becoming suspended in the indoor environment. An increase in respiratory complaints among employees who cope with wheat flour. Interstitial lung disease can be identified by High-Resolution Computed Tomography (HRCT) chest scans after exposure to wheat flour.[2] Smoking exacerbates the lung disease induced by wheat flour. The workers experienced various respiratory symptoms, including phlegm, dyspnea, chest tightness, cough, and nose irritation.[3] The pulmonary function parameters of FVC, $FEV_1$, and PEFR were significantly lower in flour mill workers compared to control volunteers. Mankar *et. al*. [4] found a significant reduction in $FEV_1$ and FVC with increasing age and a negative correlation between age and respiratory volumes ($FEV_1$ and FVC) and flow rates (PEF and FEF 25-75 percent). During the processing of flour, wheat, and oilseeds, the production of dust occurs. The amount of dust emitted depends on factors such as the specific industrial environment, the type of raw materials used, the involved processes, and the equipment utilized. As a result, workers in different agricultural sectors are exposed to varying levels of dust.[5] According to a study conducted by Pranav *et al.*,[6] the average concentration of respirable dust in the feeding-cum-sieving section of flour mills ranged from 9 to 11 mg $m^{-3}$, surpassing the recommended limit set by The Swedish National Board of Occupational Safety and Health (5 mg $m^{-3}$ for organic dust). Inhaling dust poses a significant occupational health risk, particularly to the respiratory system. Many factors, including the kind and quantity of the dust, the length of exposure, and individual immune differences, can affect the development of occupational disorders associated with dust exposure. Many studies have been conducted in many countries on the effects of dust exposure on agricultural workers, with an emphasis on flour and flour mills. According to the Central Pollution Control Board (CPCB),[7] flour and flour mills generally employ traditional and conventional technologies for processing, which are not specifically designed to minimize pollution, including dust emissions. This study explores into the health issues that flour mill workers face at work since long-term dust exposure can cause long-term lung issues. Understanding the respiratory health effects of flour dust exposure is crucial for identifying risk factors that may contribute to asthmatic responses.[8]

## Materials and Methods

### Study Area

In Odisha, there are approximately 50,000 traditional flour mills operational across the state. These mills are typically powered by electric motors or diesel engines. To investigate the occupational health hazards associated with these mills, a participatory survey was conducted. The survey employed a locally written questionnaire to gather information from fourteen units located within a 20 km radius of Bhubaneswar. For the study, participants have been selected at random from the entire flour mill workplace. There were 140 employees of flour mills in the population.

The study gathered primary data from diverse sources through the utilization of a questionnaire and environmental assessment/monitoring devices. The questionnaire encompassed closed-ended items that offered respondents a range of response options which included age group, duration of employment, educational level, and marital status. The environmental assessment/monitoring devices were employed to assess the noise level, dust particles, and illumination present in the mill. Measuring the noise level was necessary because the workers operate machines that generate loud noise, and low illumination levels, along with dust and an unsafe environment could also affect them. Measuring dust particle concentration also served the purpose of evaluating the amount of dust produced in the mill and its effect on the workers.

The questionnaire was thoughtfully designed to cover the following sections:

Section A Collected the participants' socio-demographic data.

Section B was devoted to finding any gaps in the safety and health precautions.

Section C examined how exposure to workplace dangers affects workers' safety and health.

Section D: Sought to pinpoint any dangerous behaviour by employees.

Both interviewer-administered and self-administered methods were used to gather the data. The purpose of the questionnaire was to evaluate the employees' adherence to safety regulations and their exposure to health and safety risks at work.

**Environmental Monitoring**

Environmental data like temperature, relative humidity, noise levels, dust particles, illumination, and lung function of workers were collected. The data collection was carried out for ten days. It is observed that the noise level is generally received from the moving parts of the flour mill. Almost all the mills are operated by 10/15 hp electric motors.

Flour milling operations involve the use of machinery such as grinders, sifters, and fans, which can generate high levels of noise during their operation. Exposure to excessive noise in a flour mill can lead to hazardous issues in flour mill workers. One primary concern is the potential for noise-induced hearing loss. Continuous exposure to high levels of noise can damage the sensitive structures in the inner ear, resulting in permanent hearing impairment. Workers in a flour mill who are exposed to loud noise without proper hearing protection are at risk of developing hearing loss over time. A noise level metre (make: Lutron, Model: SL-4010) was used to measure the noise levels coming from the flour mill's machinery. The device was moved around the study sites to various locations.

A lux meter is an essential tool used to measure illumination (make: Lutron, Model: LX-101A), which refers to the amount of light falling on a surface. Proper lighting is vital for ensuring a comfortable and productive work environment. By ensuring appropriate illuminance levels, organizations can promote visual comfort, reduce the risk of eye strain and glare-related issues, and ultimately enhance the well-being and performance of flour mill workers.

A dust sampler (make: TSI (Respicon), Model: Instrumex-IAQ-2500TH) is a vital device used to collect samples of airborne particles (0.3 µm- 10 µm), allowing for the assessment of dust concentration and potential hazards. Exposure to excessive dust in the workplace can have detrimental effects on the health of workers. Dust particles, depending on their composition, size, and concentration, can cause respiratory problems like allergies, and other respiratory-related illnesses. Safety covers on moving parts are pivotal in ensuring the safety of workers in the workplace. These covers are designed to protect employees from potential hazards associated with machinery and equipment with moving components. One of the primary objectives of ergonomics is to create a work environment that minimizes the risk of injury and promotes efficient and comfortable work practices. Safety covers act as a physical barrier between workers and moving parts, preventing accidental contact, and reducing the likelihood of accidents and injuries.

**Pulmonary Function Test**

Spirometry is a routine pulmonary function test for assessing lung performance. It measures the volume and air flow that one can draw in and expel out forcefully. During a spirometry test, the individual breathes into an apparatus called a spirometry, that measures the volume and rate of airflow. Spirometry typically involves a mouthpiece connected to a transducer assembly, which in turn links to an adaptor box, all ultimately connected to a computer via a serial cable 9. It is a valuable for tracking respiratory conditions like asthma, COPD, and other lung disorders.

**Data Management and Statistical Analysis**

The mean, standard deviation, and percentages were the descriptive statistics used to analyse the data. SPSS version 16 was used for the data analysis, while Microsoft Excel version 16 was used for the data analysis of the environmental monitor, noise, lux metre, dust sampler, and pulmonary function test.

**Results and Discussion**

**Occupational Characteristics of Respondents**

Occupational health complaints of the workers in the flour mill were surveyed (Table 1). Different activities are generally performed like transportation, feeding in the hopper, bagging, etc. The workers are generally socio-economically poor, have the burden of the family, lack of awareness and less knowledge about occupational problems and lack of safety measures. It has been observed that most of the work has done by male workers. A survey proforma in Odia language was prepared for this. The detail about the location of the flour mill,

its horsepower, efficiency and details about the workers (142 Nos.) involved in these flour mills was surveyed over a period of two months. The details about the age, contact number and other socio-economic parameters along with occupational health complaints during the operation were vividly collected from primary sources.

**Table 1: Occupational characteristics of selected workers. (N=142)**

| Variables | | No. of workers | Percentage (percent) |
|---|---|---|---|
| Age group, years | <25 | 21 | 11.42 |
| | 25-35 | 41 | 26.71 |
| | 35-45 | 53 | 34.28 |
| | >45 | 27 | 28.57 |
| Education | Literate | 110 | 77.46 |
| | Illiterate | 32 | 22.53 |
| Marital Status | Married | 14 | 9.85 |
| | Unmarried | 128 | 90.14 |
| Engagement, Day/year | 100-200 | 20 | 14.08 |
| | >200 | 122 | 85.95 |

After the survey work, it was observed that 21 nos. (11.42 %) were below the age group of 25 years, 41 nos. (26.7 %) were between the age group of 25-35 years, 53 nos. (35-45 %) were between the age group of 23-45 years and 27 nos. (28.5 %) above 45 years. Literate people were 110 in nos. (77.4 %) and only 22.86 % (32 nos.) were illiterate. Most of the workers engaged for more than 100-200 days (Table 1).

Generally, it is noted that the area of the flour mill ranges from 100-400 Sq. Ft., horsepower (hp) of the flour mill is 5-10 hp (Table 2). The relative humidity was observed to vary in a range of 67-75 % and temperature ranges from 27 to 34 °C. The light intensity ranges from 65 to 105 lux. These characteristics provide an overview of the workplace environment and serve as a basis for understanding the conditions in which the workers operate.

**Table 2 : Background parameters of the workplace**

| SN | Parameters | Range | Mean ± SD |
|---|---|---|---|
| 1 | Area (Sq. Ft.) | 100-400 | 130±84 |
| 2 | Power (hp) | 5-10 | 10±1.54 |
| 3 | Humidity (%) | 67-75 | 70±15 |
| 4 | Temperatures (°C) | 27-34 | 29±5 |

*The values are ±SD of 35 samples.

The physical characteristics of the flour mill workers (Table 3) provide information on various parameters related to their physical attributes. The age of the workers ranges from 26 to 62 years, height of workers ranges from 143 to 175 cm, weight varying from 52 to 78 kg. The body mass index (BMI) and body surface area (BSA) of workers ranges from 22.8 to 26.1 kg/cm$^2$ and 1.43 to 1.94 m$^2$ respectively.

These physical characteristics provide insights into the general profile of the flour mill workers, allowing for a better understanding of their physical attributes and potential implications for their work environment. The major occupational health complaints like cough, eye irritation, headache, asthma, shortness of breath, shoulder pain, back pain, and neck pain are reported by the operator (Fig 1).

**Table 3: Physical characteristics of flour mill worker**

| Sl. No. | Parameters | Range | Mean ± SD |
|---|---|---|---|
| 1 | Age (Years) | 26-62 | 33.81±18 |
| 2 | Height (Cm) | 143-175 | 161.25±13.75 |
| 3 | Weight (Kg) | 52-78 | 65±13 |
| 4 | BMI (kg/cm$^2$) | 22.8-26.1 | 24.78±1.3 |
| 5 | BSA (m$^2$) | 1.43-1.94 | 1.70±0.24 |
| 6 | Experience, years | 0-20 | 12.5±8 |
| 7 | No of workers hours in a day | 8-10 | 9±1 |

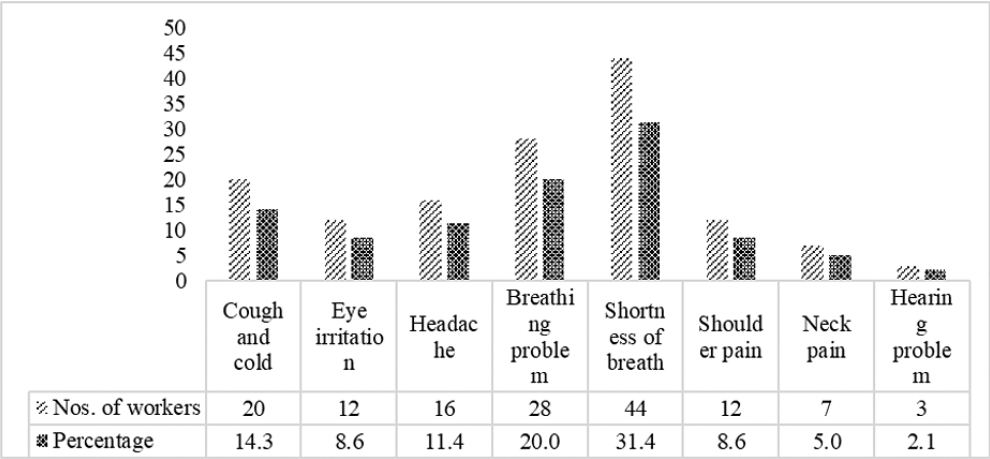


**Fig 1: Health hazard to the flour mill worker**

An occupational illness among the flour mill workers is shown in Fig 1. It lists different types of illnesses along with the number of workers affected and the corresponding percentage. The first illness listed is cough and cold, with 20 workers affected, accounting for 14.3% of the total. Eye irritation is the second illness, affecting 12 workers, which represents 8.6% of the total. Headache is reported in 16 workers, accounting for 11.4% of the total. Breathing problems are experienced by 28 workers, representing 20% of the total. Shortness of breath is reported by 44 workers, accounting for 31.4 % of the total. Shoulder pain affects 12 workers, representing 14.3% of the total, while neck pain is reported in 7 workers, accounting for 5% of the total. Finally, hearing problems are experienced by 3 workers, representing 2.1% of the total. This table provides insights into the prevalence of various occupational illnesses among flour mill workers, highlighting the specific health concerns faced by this workforce.

**Noise**

The noise level around the flour mill was measured which was found to be 79-90 dB. The exposure time of the workers is recommended to be 1 to 2 hours, where they can work comfortably. However, the workers were supplied and advised to work with ear plug, so that the noise level could be reduced to 25-28% and they could work for a longer period.

**Illumination**

Similarly, the light intensity at the work site was observed to be 65-110 lux. However, better illumination could give a better working environment eliminating stress on their eyes for which the mill owners were advised to fix extra LED bulbs at the worksite.

**Dust**

The average dust concentration such as inhalable, thoracic, and respirable was measured through

dust sampler (Model: Respicon) observed to be 21.2, 32.7 and 46.1 mg $m^{-3}$ respectively (Table 4) during the operation. The $PM_{2.5}$ and $PM_{10}$ were also measured with a direct reading type particle counter which was found to be 330–385 and 420–470 µg $m^{-3}$ respectively. However, dust concentration was found to be 39% less in the case of respirable with the attachment of an exhaust fan (Table 5).

**Table 4: Measurement of dust concentration in flour mill**

| Sl. No | Type of dust | Dust concentration |
|---|---|---|
| 1 | Respirable, mg/$m^3$ | 21.2 |
| 2 | Thoracic mg/$m^3$ | 32.7 |
| 3 | Inhalable mg/$m^3$ | 46.1 |

**Table 5: Change in dust concentration in flour mill at the different worksites after intervention**

| Sl. No | Worksite | Type of dust | | | | | |
|---|---|---|---|---|---|---|---|
| | | Respirable, mg/$m^3$ | | Thoracic mg/$m^3$ | | Inhalable mg/$m^3$ | |
| | | Before | After | Before | After | Before | After |
| 1 | $WS_1$ | 22.8 | 15.9 | 32.4 | 24.7 | 49.2 | 38.6 |
| 2 | $WS_2$ | 19.3 | 13.8 | 27.6 | 22.1 | 42.4 | 33.5 |
| 3 | $WS_3$ | 21.2 | 15.2 | 28.8 | 27.8 | 43.2 | 34.1 |
| 4 | $WS_4$ | 20.8 | 14.8 | 27.9 | 22.2 | 39.6 | 31.7 |
| 5 | $WS_5$ | 20.4 | 14.6 | 27.2 | 21.5 | 38.8 | 31.2 |

**Pulmonary Function Test**

Differences in pulmonary volume measures (including FVC, $FEV_1$, and FEV/FVC ratio) has been illustrated in Table 6, among the workers of mill depending on work experience duration. Workers with more than 15 years of work experience exhibited a considerable decline compared to those with less experience. This decline in lung function was evident when comparing workers of mill with controlled group. FVC and FEV1, critical parameters in spirometry, were notably lower in workers of mill compared to the controlled group, likely attributed to the buildup of flour dust in the airways. The decline in lung function measures with extended duration may stem from increased dust exposure, leading to greater accumulation of flour dust and subsequent ventilatory impairment.

**Table 6: Pulmonary function test parameters (Spirometry test)**

| Sl. No. | Parameters | Work experience | | |
|---|---|---|---|---|
| | | ≥ 5years | 6-14 years | ≥ 15 years |
| 1 | $FVC_{(l)}$ | 3.45 | 3.15 | 2.65 |
| 2 | $FEV_{(l)}$ | 2.54 | 2.42 | 2.10 |
| 3 | FEV/FVC (%) | 73.6 | 76.8 | 79.2 |

**Hematological Parameters of Flour Mill Workers**

The haematological test results in Table 7, including eosinophil level, total immunoglobulin E, and erythrocyte sedimentation rate (ESR), exceeded the reference range in mill employees. The elevated IgE levels may be attributed to a higher prevalence of parasitic infestation or chronic exposure to allergens. The research indicated that the increased total serum immunoglobulin E levels, eosinophil level, and erythrocyte sedimentation rate among workers or employees of mill were likely consequences of routine inhalation of milling dust. Notably, the data suggests that individuals with more years of experience tend to have slightly elevated values for absolute Eosinophil count and Total immunoglobulin E. For instance, in the "0-3 years" category, the absolute Eosinophil count is 310 cells/mm$^2$ (within the reference range of 40-440 cells/mm$^2$), while the Total immunoglobulin E is 29.6 IU/ml (compared to the reference range of up to 200 IU/ml). Meanwhile, the Erythrocyte Sedimentation Rate remains within the normal range across all categories, such as 16 mm/h (compared to the reference range of ≤ 20 mm/h) in the "0-3 years" category likewise the data from 0-3 years to greater than 15 years have been presented in Table 7. The table provides valuable insights into the relationship between working experience and these haematological and immunological markers, shedding light on potential implications for health and well-being in various occupational settings.

**Table 7: Haematological and immunological parameters in flour mill workers**

| Sl. No. | Working experience | Absolute Eosinophil count (cells/mm$^2$) | | Total immunoglobulin E (IU/ml) | | Erythrocyte Sedimentation Rate (ESR) (mm/h) | |
|---|---|---|---|---|---|---|---|
| | | Observed value | Ref. range | Observed value | Ref. range | Observed value | Ref. range |
| 1 | 0-3 years | 310 | 40-440 | 29.6 | Up to 200 | 16 | ≤ 20 |
| 2 | 3-6 years | 450 | | 27.6 | | 18 | |
| 3 | 6-9 years | 480 | | 26.1 | | 20 | |
| 4 | 9-12 years | 510 | | 24 | | 22 | |
| 5 | 12-15 years | 530 | | 22.5 | | 24 | |
| 6 | > 15 years | 550 | | 21.3 | | 25 | |

**Benefits of Intervention**

In many flour mills, it was observed that there is no demarcated fence between the machine and the working area as a result, there is every chance of encountering rotating parts of the machine with the workers which may result in accidents. Therefore, in three mills, wire mesh fencing was provided to put a barrier to avoid accidents.

Besides the workers were advised to make a habit of taking bananas and jaggery regularly which helped them to reduce the conjunction of their respiratory tract. A study conducted by NIOH involving over 2,000 participants diagnosed with COPD within a particular cohort revealed that individuals who consumed bananas demonstrated improved lung function measures over a span of three years. The research linked banana consumption to favourable clinical outcomes, such as reduced emphysema, improved walking scores, and enhanced forced expiratory volume.[10,11] During the participatory discussion, it was recorded that use of cotton material towels was mostly used on the face to get rid of dust inside the flour mill.[12]

To reduce the dust concentration exhaust fans were provided in five flour mills considering their working area. As a result, the respirable dust concentration could be reduced to a range of 35-44%. The mill owners were also advised to have openings in the workstation so that the ventilation would help in reducing dust at the site.

## Conclusion

Workers in the flour mill exhibited various health issues, including cough, cold, eye irritation, headaches, breathing difficulties, shortness of breath, shoulder pain, neck pain, and hearing problems. The most prevalent unsafe behaviour noted among respondents was working while ill, indicating inadequate occupational health and safety practices due to incomplete implementation of safety measures. Many flour mill workers lack awareness regarding the health effects of flour dust exposure, and unhealthy workplace conditions were evident during the survey, adversely impacting worker health. Notably, an increase in exposure duration among the workers of mill correlated with a remarkable decline in lung capacity, highlighting their susceptibility to pulmonary dysfunction from exposure to the dust of the milling process. Numerous epidemiological studies have linked routine inhalation of milling dust with detrimental health consequences, emphasizing the need for preventive measures. It is recommended that flour mill workers utilize personal protective equipment (PPE) during work hours and that proper ventilation and exhaust systems be installed. Additionally, safety covers should be implemented over moving parts to mitigate accidents. To foster a safety culture among workers, there should be increased awareness of behavioural-based safety practices, with safety, health, and environmental messages prominently displayed within the mills. Workers should receive education on hazard identification and adhere strictly to safety protocols. Adequate provision of PPE, along with proper training on their usage, is essential, and promoting the consumption of bananas and jaggery among workers in dusty sections can help prevent respiratory issues.

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## Conflict of Interest

The author(s) declares no conflict of interest.

## Data Availability Statement

The manuscript incorporates all datasets produced or examined throughout this research study.

## Ethics Statement

Ethical approval was taken from the Ethical committee member before the commencement of research work. The consent was also sought from the respondents who participated in the study. This study, including the participatory survey described in this manuscript has received ethical approval from an institutional ethical committee AICRP on ESA, OUAT. The research adheres to the principals outlined and was conducted by the ethical standards established by the ethical committee.

## Authors' Contribution

All authors contributed to the final version of the manuscript. Dr. Jaynarayan Mishra and Dr. Santosh Kumar Mohanty had the idea for the article. Kumudini Verma and Ipsita Rath performed the survey and prepared the manuscript. All authors reviewed the results and approved the final manuscript.

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