ADDIS ABABA UNIVERSITY
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ASSESSMENT OF RESPIRATORY SYMPTOMS AND
PULMONARY FUNCTIONS AMONG WORKERS OF FLOUR
MILLS IN ADDIS ABABA, ETHIOPIA, 2016/2017.

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ASSESSMENT OF RESPIRATORY SYMPTOMS AND PULMONARY FUNCTIONS AMONG WORKERS OF FLOUR MILLS IN ADDIS ABABA, ETHIOPIA, 2016/17.

COMPARATIVE CROSS-SECTIONAL STUDY

BY

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**Acronym and Abbreviations**

AAU: Addis Ababa University  
ACGIH: American Conference of Governmental Industrial Hygienists  
ANOVA: Analysis of Variance  
ATS: American Thoracic Society  
BMRC: British Medical Research Council Questionnaire  
BMI: Body Mass Index  
COPD: Chronic Obstructive Pulmonary Disease  
FVC: Forced Vital Capacity  
FEV₁: Forced Expiratory Volume in one second  
FEV₁ %: percentage of the FVC  
FEF₂₅-₇₅ %: Forced Expiratory Flow rate at the middle part of FVC  
ISO: International Standardization Organization  
KAP: Knowledge, Attitude, Practice  
NIOSH: National Institute of Occupational Safety and Health  
OAD: Occupational Asthma Disease  
OEL: Occupational Exposure Level  
PPE: Personal Protective Equipment  
PFTs: Pulmonary Function Tests  
PEFR: Peak Expiratory Flow Rate  
RV: Residual Volume  
SPSS: Statistical Package for Social Science  
TLC: Total Lung Capacity  
WHO: World Health Organization
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Abstract

Background: The occupational hazards such as dust and unfavorable microclimatic conditions influence human health. The occupation related lung diseases are most likely due to the deposition of dust in the lungs, which is influenced by the types of dusts, the period of exposure, the concentration and size of airborne dust in the breathing zone.

Objective: To assess pulmonary function status in workers of flour mill in Addis Ababa, Ethiopia.

Methods: The study design was comparative cross sectional and the sampling technique was convenient sampling. A total of 54 flour mill workers who work for more than eight hours shift per day and 54 control subjects matched for sex, age, weight, height and area of residence were enrolled. Anthropometric measurements was done. Respiratory symptoms were evaluated using structured questionnaire (BMRC) guidelines and administered through face-to-face interview. Lung function was measured using a digital portable spirometer (Spiro Pro) based on the ATS guidelines. FVC, FEV1, FEV1 %, PEFR and FEF25-75 %, were measured.

Result: The present study showed statistically significant reduction in the mean values of PFTs in flour mill workers as compared to their matched controls. There also exist a dose response relationship between impairment of lung function and duration of exposure. Percentage prevalence of dry cough, productive cough; wheeze and breathlessness for exposed informants were much higher than control groups. Reductions in most PFTs in study subjects were very significant for FVC (4.25±0.93 vs. 5.30±0.71, p<0.001), FEV1 (3.46±0.86 vs. 4.50±0.72, p<0.001), PEFR (5.43±2.43 vs. 7.87±2.53, p<0.001) and FEF25-75% (3.87±1.61 vs. 4.60±1.60, p<0.05), but not significant for FEV1 % (81.93±12.74 vs. 83.40±12.50, p>0.05).

Conclusion: Based on the results of the present study occupational exposure to flour dust could cause respiratory irritation, sensitization and thereby reduce lung efficiency. In summary, flour mill workers develop 27.7% of restrictive type and 11.1 % of obstructive type of lung disorders.

Key words: Flour dust, PFTs, Spirometry, Respiratory symptoms
1. Introduction

1.1. Background of the Study

Civilization, industrialization and modernization have been established to optimally fulfill various human needs. Over the course of time, some industries exert hazardous effect on the health of human beings (Tanko et al., 2011). There are significant variations in occupational health and safety performance between countries and economic sectors. Identifying occupational hazards and the health problems associated with occupational health and safety can be broadly listed as environmental assessment, biological monitoring, medical surveillance and epidemiological approaches (Alli, 2001).

Occupational lung diseases are a broad group of diagnosis caused by the inhalation of dusts, chemicals, or proteins. The severity of the disease is related to the material inhaled and the intensity and duration of the exposure. Occupational lung diseases form an important area of respiratory medicine. As a result, improper control of these substances can result in a severe threat to site workers because most of the workers are unaware of this hazardous effect on health (Guard, 1985). According to NIOSH, atmospheric pollutants, like particulates are capable of producing adverse effects under some condition(s) of exposure and dose through time (Bernstein, 2006). World-wide exposure to airborne particulates causes 386,000 deaths each year of which 38,000 asthma, 318,000 COPD and 30,000 pneumoconiosis in the world (Chanyeung et al., 2008). Rhinitis, laryngitis, tracheitis, bronchitis and bronchiolitis are also major spectrum of occupational lung disease. The sum of years of potential life lost due to premature mortality and the years of productive life lost due to disability is also high (Speizer, 2000).

Airborne dusts are particular concern to health, as they are to be associated with occupational lung diseases such as the pneumoconiosis, silicosis, bysinosis, and cardiovascular disease as well as systemic intoxications, especially at higher levels of exposure (Ahmed et al., 2009). Since recently, there is also a growing interest in other dust-related diseases, such as cancer, asthma, allergic alveolitis, and irritation, as well as a whole range of non-respiratory illnesses, which may occur at much lower exposure levels (WHO, 1999).
There is growing consensus on the deleterious effects of organic dust on respiratory symptoms and performance of industrial workers; flour dust, for instance is widely incriminated to cause such effects (Ahmed et al., 2009). Exposure to flour dust occurs across a range of food industries including grain mills, flour mills and bakeries (Mohammadien et al., 2013). Flour dust is an asthmagen and cause sensitization, allergenic rhinitis and occupational asthma among bakers and millers (Dhillon et al., 2011). Aerosols may exist in the form of airborne dusts, sprays, mists, smokes and fumes (WHO, 1999). This has an indication of the health status of these occupational mill workers (Kuschener et al., 2003).

The occupation related lung diseases in textile mill workers are most likely due to the deposition of cotton dust in the lungs (Abebe et al., 1995) and are influenced by types of dusts, the period of exposure, the concentration and size of airborne flour dust in the breathing zone (Nayak et al., 2013). A threshold limit value of 0.5 mg/m$^3$ of dust were proposed in 2009 by the American Conference of Governmental Industrial Hygienists (ACGIH) as the occupational exposure level (OEL) in breathing zones for workers in flour mills (Mahmoud, 2011). Flour dust is a heterogeneous substance with respiratory sensitizing properties and long-term exposure to it may cause acute or chronic respiratory disease (Ijadunola et al., 2005). Several studies showed that prevalence of sensitization for wheat allergens and fungal a-amylase, and prevalence of OAD, is high among workers exposed to flour dust (Meijster et al., 2007).

Two independent studies have found that flour dust exposure causes respiratory symptoms and it is associated with impairment of lung function. Flour dust also can act as an irritant and may give rise to short-term respiratory, nasal and eye symptoms, or it may provoke an asthma attack in individuals with pre-existing disease. In the UK, for example, flour and grain dust are the second most commonly cited agents associated with occupational asthma. The dust explosion hazard continues to represent a constant threat to process industries that manufacture, use and/or handle powders and dusts of combustible materials (Mahmoud, 2011; Ross et al, 1997).

The main product of mill flour is sufficiently fine to give explosive dust clouds if dispersed in air within the explosive concentration range generated by abrasion and crushing of the larger non-explosible material in the product handling processes. This can have a tendency to cause respiratory ailments (Ross et al., 1997). Poor ventilation is a basic problem in flour mills (Wagh
et al., 2006) that have continuous exposure of workers. Exposure to fine dust that leads to pulmonary and respiratory diseases (Mengesha et al., 1998).

1.2. Statement of the Problem

There are probably hundreds of millions of people worldwide exposed to hazardous dusts in the course of their work. There are more than 250 million work-related accidents every year (Alii, 2001). Workplace hazards and exposures cause over 160 million workers to fall ill annually, while it has been estimated that more than 1.2 million workers die because of occupational accidents and diseases (Alii, 2001).

Agriculture, basic food processing and extractive industries are very widespread and can lead to dust exposure (Melse et al., 2009). In many countries, several studies investigated pulmonary function and respiratory symptoms in occupational workers worldwide (Hosseinabadi et al., 2013). Work-related lung disease and its workforce exposure includes sandblasters, miners, millers, potters, glassmakers, foundry and quarry workers, abrasive workers silica flour mixers, and construction workers. According to WHO data (1999), occupational work which generates dust easily leads to exposures of more than ten and sometimes hundreds of mg/m$^3$ explosive organic and inorganic materials. Globally studies on dust exposures have been documented in different occupational exposure that affects human health. Occupational accidents and diseases are still too frequent. High exposure levels to total and respirable dust in occupational workers induce respiratory ailments.

Unpublished studies in Ethiopia has documented the effects of occupational dust exposure. For instance, studies on effect of stone dust and wood dust on cardio-respiratory function showed increased respiratory symptoms, such as chest pain, cough, breathlessness, which increased risk of development of asthma, chronic bronchitis and impair lung function (Hailemariam, 2013; Nigisti, 2014). Petrol fume was also found to cause a devastating effect on different physiological systems especially on respiratory system (Temesgen, 2015).

In Ethiopia, there was no documented data related to the effect of flour dust on pulmonary function among flour mill workers. The present study is therefore undertaken to assess the respiratory symptoms and pulmonary function problems related to flour mill workers.
1.3. Rationale of the study

This study was aimed to document pulmonary function tests of flour mill workers who were exposed to flour dust.

The workers have limited knowledge on the effect of flour dust to their health, and in effect, they have been victims for several years of their stay in the mill. This study aims to investigate the effect of flour dust on the pulmonary function by analyzing the PFTs that will estimate the effectiveness of the lung and recommend the best solution to stakeholders. It was also proposed to reduce the risk of developing respiratory diseases.

The finding of this study is important to Department of Occupational Safety and Health within the Ministry of Labor and Social Affairs office of industrial development bureau in Ethiopia. It will also encourage communication between various concerned groups and organizations, and foster an improved understanding of the potential problems of flour dust in the country.

The finding of this study may also help to fill a knowledge gap by providing relevant evidence-based data on the impairment of pulmonary function from a population who have little information like Ethiopia. Identified the nature of pulmonary function complications and related factors in mill workers exposed to flour dust for a long period.

Finding out the hazardous effect of flour dust and subsequent awareness creation campaign about flour dust induced pulmonary complications can minimizes unnecessarily health cost. Therefore, the results of this study will invite stakeholders for further studies on the flour mill workers.
2. Hypothesis

Pulmonary function parameters of flour mill workers are lower than non-exposed controls. There is significant difference between pulmonary function parameters of flour mill workers population versus the comparable control groups.
3. Literature Review

3.1. Dust Found in Working Environment

Dusts can be defined as solid particles, ranging in size from below 1μm up to at least 100μm (Lundberg, 1998) which may be or become airborne, depending on their origin, physical characteristics and ambient conditions (Noor et al., 2000). Dusts are generated by handling, crushing, grinding, rapid impact and detonation of organic or inorganic materials, such as rock, ore, metal, coal, wood, grain and spice (Iyawe et al., 2000).

The major dust materials found in the environment includes mineral dusts, such as those containing free crystalline silica (e.g., as quartz), coal and cement dusts; metallic dusts, such as lead, cadmium, nickel, and beryllium dusts; other chemical dusts, e.g., many bulk chemicals and pesticides. Organic and vegetable dusts includes, such as flour, wood, cotton and tea dusts, pollens; biohazards, such as viable particles, moulds and spores (WHO, 1999).

An organic and vegetable dust like flour dust includes cereals and spices. The American Conference of Governmental Industrial Hygienists (ACGIH) defines ‘flour’ as a complex organic dust containing cereals like wheat (Triticum sp.), rye (Secale cereale), sorghum (Panicum miliaceum), barley (Hordeum vulgare), oats (Avena sativa), rice (Oryza sativa) or corn (maize) (Zea mays), or a combination of these, which have been processed by milling (Stobnicka et al., 2015). Flour is a powdery finished product of cereals obtained after the cereals have undergone several reduction processes. These reduction processes leads to the generation of gaseous chemical compounds and organic dust (Urom et al., 2015).

Spices and herbs dust originates mainly from cinnamon (Cinnamomum zeylanicum), cloves (Syzygium aromaticum), mustard (Brassica nigra), garlic (Allium sativum), onion (Allium cepa), ginger (Zingiber officinale), coriander (Coriandrum sativum) and other spices and condiments, which contains highly toxic ingredients to cause respiratory system. They contain volatile organic substances, often called aromas. These substances belong to different chemical groups like aldehydes and ketones (Chirane, et al., 2009).

Spices and aromatic herbs are valued for their organoleptic properties. Certain spices and herbs are associated with health and sensitization problems when they are exposed to skin, or when
workers inhale dusts during processing activities (Van Der Walt et al., 2013). Occupational exposure to spice and herb dust can cause respiratory symptoms and diseases (Swan et al., 2007).

3.2. Components of Flour Dust

Table 1: Substances that are found in flour dust on consensus report for flour dust (Lundberg, 1998).

<table>
<thead>
<tr>
<th>Components</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain</td>
<td>Glycoproteins, starch</td>
</tr>
<tr>
<td>Spices and</td>
<td>Anise, cardamom, cinnamon, cloves, ginger, lemon, peppermint</td>
</tr>
<tr>
<td>flavorings</td>
<td></td>
</tr>
<tr>
<td>Biological agent</td>
<td>Insects, weevils and rice beetles, fungi</td>
</tr>
<tr>
<td>Others</td>
<td>Impurities in the form of solids, dusts, fibers, aerosols</td>
</tr>
</tbody>
</table>

3.3. Biological and Physical Characteristics of Flour Dust

In terms of biological activity, cereals belonging to the family poaceae derived from wheat, rye, barely, rice, sorghum and others cereals produce flour during milling. Flour dusts have large number of contaminates including silica, fungi, and their metabolites (aflatoxins), bacterial endotoxins, insects, various chemical additives such as pesticides and insecticide so persons working in milling exposed to high allergenic potency to cause respiratory disease (Waghn et al., 2006).

The aerodynamic sizes of flour dust particles, their kinetics in the lungs follows the pattern of other particulate aerosols of a similar type, and their deposition within the respiratory tract is determined by the particle size, shape, density as well as by the respiration volume. Particles with sizes between 5μm and 10μm may provoke asthmatic reactions. Particles below 5μm may evoke an allergic alveolitis type of reaction (Stobnicka et al., 2015).
3.4. Uptake and Exposure of Flour Dust

Accumulation of large enough burdens of insoluble particles in the respiratory tract leads to impaired clearance. This so-called dust overload sequestered or fixed in the tissue exposures through deposition of dust in the respiratory tract (Pope III et al., 2002).

**Figure 1:** Penetration and deposition mechanism of dust particles in human respiratory regions

A significant fraction of the inhaled particles do deposit within the respiratory tract. It governs the lung response substantially to dust deposition. Sedimentation and inertial impaction is one mechanism of dust deposition like large particle 1-100μm deposited through nose, trachea and conducting airways. Small particles size < 0.1μm is deposited by diffusion in the gas exchange portion of the lung. Particle less than 0.001μm most of them exhaled out and <10% them deposited in the lungs (Weinhold , 2005).
The European committee for standardization and particle size-selective criteria defined three fractions for health-related measurement. In the respiratory tract inhaled through the nose and mouth are considered as inhalable fraction. Within the lung airways including the gas-exchange region below the larynx (tracheobronchial region) the deposited particulate matter are thoracic fraction. The respirable fraction are total inhalable dust breathes in to mouth and nose plus respirable dusts breathe in to alveoli (Lundberg, 1998; WHO, 1999). The respirable dust fraction refers to the mass fraction of inhaled particles, which penetrate to the alveoli (50% cut-off point at 4μm). The thoracic dust fraction refers to the mass fraction that enters the tracheobronchial region (50% cut-off point at 10μm) and the inhalable dust fraction refers to the mass fraction that enters the mouth and nose (50% cut-off point at 100μm) (Zeleke, 2011; Siyoum, k et al., 2014).
Table 2: Particle size distribution in flour mill into the lung from range minimum 1μm to maximum 80μm (Weinhold, 2005).

<table>
<thead>
<tr>
<th>No</th>
<th>Deposition</th>
<th>Rang of particle size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Particle that can be inhaled through the nose</td>
<td>0.0001-100μm</td>
</tr>
<tr>
<td>2</td>
<td>Particle that are respirable of reaching deep in to the lung</td>
<td>0.0001-10μm</td>
</tr>
<tr>
<td>3</td>
<td>Milled flour dust size</td>
<td>1-80μm</td>
</tr>
</tbody>
</table>

3.5. Pulmonary Function Tests

PFTs are noninvasive tests, used to detect airflow limitation and/or lung volume restriction. Dynamic lung function tests are based on time, i.e. the rate at which air flows into or out of lungs. Dynamic compliance includes the pressure component due to airway resistance (Jonathan et al., 2009).

3.6. Spirometry

Spirometry is a medical test that measures the volume of air an individual inhales or exhales as a function of time to see the objective assessment of pulmonary function and respiratory disorders. In clinical practice, lung diseases are classified as obstructive, restrictive or combination of the two forms (Miller, et al., 2005).

Spirometry plays a fundamental role in medical surveillance investigations for occupational lung diseases, in determining whether to institute preventive or therapeutic measures, and in granting benefits to individuals with lung impairment (Nici et al., 2006). It also plays a significant role in the diagnosis and prognosis of these diseases and shows the effect of restriction or obstruction on lung function (Hosseinabadi et al., 2013)
3.7. Restrictive and Obstructive Lung Disease

**Figure 3:** Flow-volume curves in obstructive and restrictive lung disease.

3.7.1. Restrictive Lung Disease

Restrictive respiratory diseases are abnormal respiratory conditions characterized by difficulty in inspiration. Large amount of elastic work is needed to inflate the lungs. Expiration however, is not affected. Restrictive respiratory diseases may arise from abnormality of lungs, thoracic cavity or/and the nervous system. The FEV₁: FVC ratio is normal or increased (K.Sembulingam, *et al.*, 2012).

**Figure 4:** Spirograms showing restrictive lung disease
3.7.2. Obstructive Lung Disease

Obstructive respiratory diseases are abnormal respiratory conditions characterized by difficulty in expiration, which reduces dynamic airway collapse and resistive work of breathing. Obstruction of the airways leads to airflow limitation. These includes lower respiratory tract diseases such as asthma, chronic bronchitis, emphysema (K.Sembulingam, et al., 2012). The airway obstruction is not often fully reversible even with medication leading to chronic obstructive pulmonary disease. Asthma, chronic bronchitis and emphysema are major category of chronic obstructive pulmonary disease (Maio et al, 2012). In chronic bronchitis, for instance airflow limitation is caused by obstruction of small airways in the lung mainly due to inflammation and excessive bronchial mucus secretion. In emphysema however, airflow limitation is caused by the destruction of elastic septal tissue in the respiratory part of the lung where gas exchange occurs (respiratory bronchioles and alveoli), resulting in air trapping and decreased oxygen supply to the body. The FEV₁: FVC ratio is significantly decreased. TLC increase or normal. FVC is normal or decrease (Jonathan et al., 2009).

Figure 5: Spirograms showing obstructive lung disease
FEV$_1$ and FVC are graphically represented as restrictive and obstructive patterns during the first one second shown below.

**Figure 6:** Measurement of forced expiratory volume during one second (FEV$_1$) and forced vital capacity (FVC) in restrictive and obstructive lung disease (John and West, 2012).

The spirometry result of pulmonary function tests were interpreted as follows:

- FEV$_1$/FVC ratio $<$0.7 indicates an obstructive disorder. FEV$_1$ has fallen to a greater degree than the FVC. FVC may decrease or normal. FEV$_1$ value $<$80% predicted normal is used to interpreted the obstructive pattern disorder (Al-Ashkar et al., 2003).
- FEV$_1$/FVC ratio $>$0.7 that suggests the presence of a restrictive defect. Both FEV$_1$ and FVC value are reduced. FVC value $<$80% predicted normal is used to interoperated the restrictive pattern disorder. FEV$_1}$/ FVC ratio $>$ 0.7 (Al-Ashkar et al., 2003).
3.8. Conceptual Framework of the Study

Socio-demographic characteristics
- Age
- Sex
- Occupation

Other factors
- Physical exercise
- Diet
- Smoking
- Altitude

Pulmonary function tests
- FVC,
- FEV\(_1\),
- FEV\(_1\)/FVC %
- FEF\(_{25-75}\) %,
- PEFR.

Anthropometric measurement
- Weight
- Height
4. Objectives

4.1. General Objective:

- To assess pulmonary function status among flour mill workers in Addis Ababa, Ethiopia

4.2. Specific Objectives

- To assess pulmonary function tests of workers in the flour mill
- To evaluate the effect of flour dust exposure in inducing respiratory symptoms
- To assess the relationship between duration of exposure to flour dust and change in respiratory function
- To compare the pulmonary function parameters of flour mill workers and controls
5. Operational Definitions

**Respiratory symptoms:** Classified as lower respiratory tract symptoms (dry cough, productive cough, chest tightness, and shortness of breath) or upper respiratory tract symptoms.

**Productive Cough:** Cough with expectoration

**Dry Cough:** Cough without sputum

**FVC:** The maximum amount of air that can be exhaled following a maximal inspiration effort. It is measured in liters. Subjects should aim for an expiration lasting a minimum of six seconds.

**FEV₁:** The volume of air exhaled in the first second during a forced vital capacity effort. Average values for FEV₁ in healthy adults depend mainly on sex and age.

**FEV₁/FVC (FEV₁%):** The percentage of the FVC expired in the first second of maximal forced expiration following full inspiration. Predicted values greater than 80% is usually considered as normal.

**FEF25-75 % or mid expiratory flow:** Indicates expiratory flow in the middle portion of the FVC.

**Peak expiratory flow (PEF) or peak expiratory flow rate (PEFR):** The maximum rate of airflow during the FVC maneuver in L/min.

**Obstructive disorder:** FEV₁/FVC ratio <0.7 and percent predicted FEV₁ <80% predicted normal, FVC value reduced or normal.

**Restrictive defect:** FEV₁/FVC ratio >0.7. FEV₁ reduced, FVC value <80% predicted normal.
6. Materials and Methods

6.1. Study Area
The study was conducted in lideta sub-city; Addis Ababa, Ethiopia. Addis Ababa encompasses 10-sub cities and 116 woredas. It is located at altitude of 2,400 meter above sea level. Based on the data from Lideta sub-city trade and development bureau and urban agriculture corporation, ten of 116 weredas are located in lideta sub city containing a total of 76 flour mills during a time of data collection.

6.2. Study Period
This study was conducted in flour mill workers, Addis Ababa, Ethiopia, for a period of one months between August, 21 up to September, 25, 2016.

6.3. Study Design
Comparative cross sectional study design was employed to assess respiratory symptoms and pulmonary function parameters in workers of flour mill in Addis Ababa, Ethiopia, 2016.

6.4. Source Population
The source populations are all flour mill workers in Addis Ababa city, Ethiopia.

6.5. Study Population
Study Group: flour mill workers in Lideta sub-city in the age range between 18 to 43 years and fulfill the inclusion criteria. All subjects were male as there were no female workers in the flour mill industry in the selected sites during the study period.

Control Group: non flour mill workers in Lideta subcity matched for age, sex, height and weight to flour mill workers and fulfill inclusion criteria.

6.6. Eligibility Criteria

6.6.1. Inclusion Criteria
Millers who were available in the work place between the age range of 18-64 years and working in the flour mill for more than one-year were included. All the subjects, which were not in the exclusion criteria, were included.
6.6.2. Exclusion Criteria

Subjects with gross clinical abnormalities of the vertebral column, thoracic cage, neuromuscular diseases, known cases of gross anemia, diabetes mellitus, pulmonary tuberculosis, hypertension, drug addicts, known cardio pulmonary disease, cigarette smokers, tobacco and khat chewers, bakery workers and those who underwent vigorous exercise, abdominal or chest surgery were excluded from the study.

6.7. Sample Size

The following double proportions (two-sided) formula were used for the determination of sample size (Habib et al., 2014).

\[
n = \frac{(\bar{p})(1 - \bar{p}) \left( \frac{Z_{\alpha}^2 + Z_{\beta}^2}{2} \right) \left[ \frac{r+1}{r} \right]}{E^2}
\]

where \( \bar{p} (1 - \bar{p}) \) is a measure of variability (similar to standard deviation) and \( \bar{p} = \frac{(p_1 + p_2)}{2} \).

\( E = p_1 - p_2 \) is the effect size (the difference in means or proportions).

\( n \) = required minimum sample size for the cases

\( p_1 \) (Prevalence of event in cases) = 0.37

\( p_2 \) (Prevalence of event in controls) = 0.13

\( E^2 \) (effect size difference in proportion) = (0.37-0.13)^2 = 0.06

\( \bar{p} = (p_1 + p_2)/2 = 0.37 + 0.13/2 = 0.25 \)

\( Z_{0.025} \) (1.96 at 95% level of significance)

\( Z_{0.8} \) (0.84 for 80% power of the test)

\( r \) (proportion of controls to cases) = 1

By taking the proportions from previous study on association of flour dust on PFTs and prevalence of respiratory symptoms of chronic cough for flour mill workers and control groups (37% to 13% respectively) (Taytard et al., 1988), the sample size was calculated as:
\[ n = \frac{(\bar{p})(1 - \bar{p}) (Z_{\alpha/2} + Z_{\beta})^2}{E^2} \left[ \frac{r+1}{r} \right] \]

\[ n = (0.25) \times (1-0.25) \times (1.96+0.84)^2 \times [1+1] \]

\[ = (0.37-0.13)^2 \quad 1 \]

\[ n = (0.25) \times (0.75) \times (7.84) \times (2)/0.06 = 49 \]

By considering double proportion the required sample becomes 98 study participant and including 10% non-response rate the total sample size was 108. Among them 54 participants were flour mill workers and 54 study participants were non-flour mill workers.
6.8. Sampling Procedures

All flour mill workers in the mill and matched non-flour mill workers in Addis Ababa, lideta sub-city. Lideta sub-city was selected based randomly by lottery method of the ten sub cities.

Lideta sub city contains 10 woredas and 76 flour mills

Among 10 woredas 4 woredas were selected by random sampling.

Flour mill workers and controls fulfilling inclusion criteria

Flour mill workers and controls age 18-64 years selected by convenient sampling technique

Selected flour mill workers and controls were interviewed and anthropometry was measured and spirometry was done

54 flour mill workers and 54 controls totally n=108 was enrolled.
6.9. Variables

6.9.1 Dependent Variable

The dependent variables includes: FVC, FEV₁, FEV₁ %, PEFR, FEF₂₅₋₇₅ % and respiratory symptoms (productive cough, dry cough, chest tightness, breathlessness, wheezing)

6.9.2. Independent Variables

- Socio-demographic characteristics: Age, Sex, Marital status, Occupation
- Duration of exposure, protective device
- Anthropometric Data: Weight (Kg), Height (meter)

6.10. Data Collection Procedures

Under direct supervision by the principal investigator and three postgraduate physiology students were collected and recorded the data. Each participant were informed about the objective of the study and the benefit associated with the study immediately before sample collection. Millers who were volunteered to participate in the study have answered questions in the questionnaire, which were relevant to their socio-demographic information. Both the anthropometric and spirometric data were measured.

6.10.1. Anthropometric Measurements

Height and weight of the study participants were measured. The height was measured without shoes by the use of a meter rule and approximated to the nearest one cm. Weight was also measured using weighing scale (nearest to one Kg), with light clothing and without phones or any encumbrance that could alter their appropriate weight. Body mass index (BMI) was calculated through this formula: Weight/squared height (kg/m²)

6.10.2. Questionnaires

The questionnaire containing information based on British Medical Research Council Questionnaire (BMRC) was used to assess socio-demographic data, respiratory symptoms; occupational history and use of personal protective equipment (PPE). Questionnaires by the American Thoracic Society (ATS) were also used to assess lung function parameters. The questionnaires were prepared in English, translated to local language to Amharic, and re-translated back to English, to keep consistency of the questions.
6.10.3. Spirometric Measurement
Digital pocket-sized Spiropro (JEAGER, Germany) was used to measure pulmonary function indices. Spirometric tests in both exposed and control subjects were done as follows. Before every test, the mouthpiece was disinfected in standard solution and then attached to the spirometer. Subjects were told to put the nosepiece on the nose to prevent air blowout. Then, they were also instructed to breathe in fully until their lung filled maximally. Precaution were taken to avoid leakage from mouth pieces. The subjects expire forcefully and as fast and complete as possible until there is no more air left to expel. Spirometric measurements were performed in sitting position and at a fixed time of the day at room temperature (20-25°C), to minimize diurnal variations. The measurements were done in three trials, and one of the three trials, which was the best, was taken and interpreted. Prior to the actual tests, calibration with one-liter syringe and familiarization steps were done.

![Digital spirometer and its components to perform PFTs](image)

**Figure 7:** Digital spirometer and its components to perform PFTs
6.10.4. Data Quality Control

The quality of the data was controlled carefully. The spirometer and the weight scale were calibrated daily. Validity of the questionnaire was maintained by performing pretest in 5% of the sample size (on 6 subjects). Each completed questionnaire was checked immediately to ascertain that all the questions were answered consistently and incomplete data was discarded. Then the information was entered into computer and rechecked carefully. The hard copies of the questionnaire and result were kept secure and confidential.

6.11. Data Processing and Statistical Analysis

Statistical software package (SPSS V 20.0) was used for analysis using figures, tables. Descriptive statistics was used to summarize anthropometric measurements of subjects, personal and occupational information of exposed and control subjects.

Binary logistic regression and odds ratio were used to analyze and estimate the prevalence of respiratory symptoms.

Independent sample t-test was used to compare the mean respiratory scores of exposed and control groups.

One way analysis of variance (ANOVA) and student t-test were used for testing the strengths of the associations with its statistical significant difference in respiratory system measurements between groups.

Pearson’s correlation coefficient was also used to quantify the degree of linear relationship between pulmonary function test and duration of exposure.

6.12. Ethical Consideration

The study was carried out after ethical clearance and approval was obtained from research committee of the department of Physiology, Addis Ababa University. The study participants were briefed on the objective and procedures of the study. Thereafter, both verbal and written informed consents were obtained from those volunteers and were selected for the study. Confidentiality was kept in place and code numbers were used to identify the subjects. In addition, the personal data collected during this study were used only for the stated objectives. The participants had a full right to refuse or discontinue the study at any point of the study.
7. Results

7.1 Socio Demographic Characteristics

All workers included in the study were males. The age of the flour mill workers ranged between 18–43 years with a mean of 27.37±6.71 years while the age of the comparison group ranged between 18–43 years with a mean of 28.00±5.33 years (Table 3). The age difference between flour mill workers and control groups was not statistically significant (Table 4).

Table 3: Socio-demographic information of flour mill workers and controls in lideta sub city, Addis Ababa, Ethiopia, 2016/17.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Descriptions</th>
<th>Flour mill workers (n=54)</th>
<th>Control Group(n=54)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age range (in years)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-23</td>
<td>37.03% (n=20)</td>
<td>20.04% (n=13)</td>
<td></td>
</tr>
<tr>
<td>24-28</td>
<td>27.7% (n=15)</td>
<td>37.03 (n=20)</td>
<td></td>
</tr>
<tr>
<td>29-33</td>
<td>12.9% (n=7)</td>
<td>22.2% (n=12)</td>
<td></td>
</tr>
<tr>
<td>34-38</td>
<td>11.1% (n=6)</td>
<td>12.9% (n=7)</td>
<td></td>
</tr>
<tr>
<td>39-43</td>
<td>11.1% (n=6)</td>
<td>3.7% (n=2)</td>
<td></td>
</tr>
<tr>
<td>Educational status</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illiterate</td>
<td>16.6% (n=9)</td>
<td>“-”</td>
<td></td>
</tr>
<tr>
<td>Can write and read</td>
<td>35.1% (n=19)</td>
<td>7.4% (n=4)</td>
<td></td>
</tr>
<tr>
<td>Grade 8 complete</td>
<td>27.7% (n=15)</td>
<td>1.8% (n=1)</td>
<td></td>
</tr>
<tr>
<td>Grade 10 complete</td>
<td>14.8% (n=8)</td>
<td>27.7% (n=15)</td>
<td></td>
</tr>
<tr>
<td>Grade 12 complete</td>
<td>1.8% (n=1)</td>
<td>33.3% (n=18)</td>
<td></td>
</tr>
<tr>
<td>Diploma</td>
<td>“-”</td>
<td>11.1% (n=6)</td>
<td></td>
</tr>
<tr>
<td>1st degree</td>
<td>3.7% (n=2)</td>
<td>18.5% (n=10)</td>
<td></td>
</tr>
<tr>
<td>Marital status</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td>68.5% (n=37)</td>
<td>64.8% (n=35)</td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>25.9% (n=14)</td>
<td>31.4% (n=17)</td>
<td></td>
</tr>
<tr>
<td>Divorced</td>
<td>5.5% (n=3)</td>
<td>3.7% (n=2)</td>
<td></td>
</tr>
</tbody>
</table>

7.2. Use of Personal Protective Equipment

The use personal protective devices utilization and the types of personal protective equipment used by the workers were investigated. We found, 57.4% (n=31) do not wear any equipment, 9.3% (n=5) wear safety shoe, masks and gloves, 33.3% (n=18) wear only masks (Figure 8).
We observed that there is no sufficient personal protective device in the work place and the workers do not wear the equipment timely even if the material is available.

Among the study subjects, 92% of the informants agreed with the idea that all flour mill workers should wear personal protective devices (Figure 8).

![Figure 8: Bar chart indicating the use of personal protective equipment](image)

**7.3. Anthropometric Measurements**

Anthropometric parameters of the study subjects in terms of demographic variables demonstrate the comparison between the flour mill workers and their matched control subjects. There were no significant differences between the means of anthropometric parameters (physical parameters): in terms of age, weight, height and BMI between the groups. The statistical comparison of the matching variables (age, height, weight and BMI) shows no difference between the two groups (Table 4).
Table 4: The anthropometric measurements for flour mill workers and control groups by independent sample t-test.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Exposed group (n=54)</th>
<th>Non exposed group (n=54)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ±SD</td>
<td>Mean ±SD</td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>27.37±6.71</td>
<td>28.00±5.33</td>
<td>0.591</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>59.72±7.76</td>
<td>61.91±6.39</td>
<td>0.113</td>
</tr>
<tr>
<td>Height (meter)</td>
<td>1.66±0.07</td>
<td>1.68±0.05</td>
<td>0.388</td>
</tr>
<tr>
<td>BMI (kg/m$^2$)</td>
<td>21.42±2.25</td>
<td>21.95±1.82</td>
<td>0.185</td>
</tr>
</tbody>
</table>

P>0.05 is statistically not significant

7.4. Respiratory Symptoms

The percentage prevalence’s of dry cough, productive cough, wheeze and breathlessness were 27.7%, 11.1%, 14.8% and 16.6% for exposed informants respectively and 9.3%, 5.6%, 3.7% and 7.4% for control subjects, respectively (Table 5). These values were higher among exposed workers as compared to control groups and the difference was statistically significant for dry cough (p<0.05). No chest tightness symptoms observed in both the flour mill workers and the control groups.

Binary logistic regression was used to compare the respiratory symptoms and measure the strength of the association. The odds of dry cough in flour mill workers exposed to flour dust was 3.58 times (crude OR=3.58, 95% CI: 1.16, 11.65) greater than it was in controls. The association was found to be statistically significant (p<0.05).

The odds of breathlessness was 2.80 times (crude OR=2.80, 95%CI=0.78-10.09) higher for exposed respondents than for non-exposed respondents but, the association was found to be statistically not significant (P>0.05).
The informants exposed to flour mill dust and had productive cough with odds ratio 1.76 times (crude OR=1.755, 95%CI: 0.39, 7.98) higher than the non-exposed group and the association was found to be not significant (P>0.05).

The odds of wheeze was 4.25 times (Crude OR= 4.25, 95%CI=0.83 -21.88) higher for exposed respondents. However the association was found to be statistically not significant (P>0.05).

**Table 5:** Respiratory symptoms of exposed and non-exposed subjects including OR and 95% CI.

<table>
<thead>
<tr>
<th>Respiratory symptoms</th>
<th>Prevalence % (n=54)</th>
<th>OR</th>
<th>P-value</th>
<th>95% CI</th>
<th>Lower</th>
<th>upper</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dry Cough</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case</td>
<td>27.7%(n=15)</td>
<td>3.58</td>
<td>.027*</td>
<td>1.16</td>
<td>11.65</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>9.3%(n=5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Productive cough</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case</td>
<td>11.1%(n=6)</td>
<td>1.76</td>
<td>.467</td>
<td>0.39</td>
<td>7.98</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>5.6%(n=3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Wheeze</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case</td>
<td>14.8% (n=8)</td>
<td>4.25</td>
<td>.084</td>
<td>0.83</td>
<td>21.88</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>3.7%(n=2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Breathlessness</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case</td>
<td>16.6%(n=9)</td>
<td>2.80</td>
<td>.115</td>
<td>0.78</td>
<td>10.09</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>7.4%(n=4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*P<0.05 is statistically significant

### 7.5. Pulmonary Function Tests

Changes in percent-predicted lung function tests of exposed and control groups were indicated in (Table 6). There was a statistically more significant reduction in the predicted score of the exposed group than in healthy control group. Percentage predicted values of control group have largest score when compared to that of the exposed group. The difference was statistically significant (p<0.05). However, for FEV1% difference is not significant (p>0.05).
**Table 6**: Percent predicted lung function tests of exposed and control groups.

<table>
<thead>
<tr>
<th>Pulmonary function test Parameters</th>
<th>Groups( case n=54 and control n=54)</th>
<th>Mean ±SD</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prediction of FVC(L)</td>
<td>case</td>
<td>88.59±19.05</td>
<td>0.000**</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>107.98±14.05</td>
<td></td>
</tr>
<tr>
<td>Prediction of FEV&lt;sub&gt;1&lt;/sub&gt; (L)</td>
<td>case</td>
<td>87.80±20.47</td>
<td>0.000**</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>108.93±16.98</td>
<td></td>
</tr>
<tr>
<td>Prediction of FEV&lt;sub&gt;1&lt;/sub&gt;%</td>
<td>case</td>
<td>98.56±15.99</td>
<td>0.271</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>102.01±16.35</td>
<td></td>
</tr>
<tr>
<td>Prediction of PEFR(L/s)</td>
<td>case</td>
<td>59.76±25.37</td>
<td>0.000**</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>83.00±27.32</td>
<td></td>
</tr>
<tr>
<td>Prediction of FEF&lt;sub&gt;25-75&lt;/sub&gt;% (L/s)</td>
<td>case</td>
<td>88.83±35.08</td>
<td>0.001*</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>115.09±31.34</td>
<td></td>
</tr>
</tbody>
</table>

**=highly significant (P<0.001)

The independent sample t-test (Figure 9) for equality of means between two independent groups showed that there is a significant reduction in pulmonary function values of exposed group than in the control (p<0.05). The comparison of the mean respiratory score of flour-mill and controls groups (Mean ±SD) indicates FVC, FEV<sub>1</sub> and PEFR are highly significant (P<0.001) and FEF<sub>25-75</sub>% are significant (P<0.01).

The forced expiratory flow rate at the middle fifty percent (FEF<sub>25-75</sub>%) of the exposed group was lower (3.87 L/s) than that of the controls (4.60 L/s), and this reduction in flow rate was statistically significant (P <0.01).

The PEFR in flour mill workers of the exposed group was lower (5.43 L/s) than that of the controls (7.87 L/s) this reduction was statistically significant (P<0.001).
7.6. Dose-Response Relationships between Duration of Exposure and PFTs

There was slight reduction in pulmonary function indices (FVC, FEV₁, PEFR and FEF₂₅₋₇₅ %) as the duration of exposure increases. The association, however, is not statistically significant (Table 7).

**Table 7:** Mean difference of lung function measurement between duration of exposure of flour mill workers

<table>
<thead>
<tr>
<th>Pulmonary function parameters</th>
<th>Duration of exposure in years</th>
<th>1-4 years</th>
<th>5-8 years</th>
<th>&gt;=9 years</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC(L)</td>
<td></td>
<td>4.32±.91</td>
<td>4.28±.48</td>
<td>3.64±.78</td>
<td>0.053</td>
</tr>
<tr>
<td>FEV₁(L)</td>
<td></td>
<td>3.45±.95</td>
<td>3.56±.60</td>
<td>3.31±.82</td>
<td>0.881</td>
</tr>
<tr>
<td>PEFR(L/s)</td>
<td></td>
<td>5.73±2.86</td>
<td>4.81±1.43</td>
<td>4.01±1.89</td>
<td>0.349</td>
</tr>
<tr>
<td>FEF₂₅₋₇₅%(L/s)</td>
<td></td>
<td>4.08±1.53</td>
<td>4.10±2.04</td>
<td>3.70±1.50</td>
<td>0.403</td>
</tr>
</tbody>
</table>

Mean ±SD, n=54

P>0.05 is not statistically significant
Bivariate correlation result showed negative correlation between FVC and duration of exposure which was found to be statistically significant ($r = -0.417$, $p < 0.001$). Furthermore, a negative correlation were found between duration of exposure and FEV$_1$ ($r = -0.359$, $p < 0.001$), PEFR ($= -0.236$, $P < 0.05$) (Table 8).

**Table 8:** Pearson correlation coefficient results between pulmonary function parameters and duration of exposure among flour mill workers in lideta sub city, Addis Ababa, Ethiopia, 2016/17

<table>
<thead>
<tr>
<th>Variables</th>
<th>“r” –value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC</td>
<td>-0.417</td>
<td>0.000**</td>
</tr>
<tr>
<td>FEV$_1$</td>
<td>-0.359</td>
<td>0.000**</td>
</tr>
<tr>
<td>FEV$_1$%</td>
<td>0.060</td>
<td>0.535</td>
</tr>
<tr>
<td>PEFR</td>
<td>-0.236</td>
<td>0.014*</td>
</tr>
<tr>
<td>FEF$_{25-75}$ %</td>
<td>-0.156</td>
<td>0.123</td>
</tr>
</tbody>
</table>

**p < 0.001   *p < 0.05**
7.7. Pulmonary Function Status

The ventilatory impairment of flour mill workers were categorized on the bases of airflow obstruction and restrictive defects. We found that flour mill workers were suffering from both airflow obstruction and restrictive defects. Hence, the results indicate reduction in the pulmonary function efficiency among the flour mill workers.

Flour mill workers were suffering from both airflow obstruction and restrictive defects. Among 54 flour mill workers 27.7% (n=15) developed restrictive and 11.1% (n=6) developed obstructive type of lung disorder. The rest of the study subjects 61.1% (n=33) had normal pulmonary function. Two subjects (3.7%) in the control group developed obstructive type of lung disorder and the rest of the subjects had normal pulmonary function.

Figure 10: Bar chart showing the number of obstructive, restrictive and normal pattern of lung function in controls and flour mill workers.
8. Discussions

Long-term continuous exposure to fine dust is known to result in pulmonary and respiratory disease. The dust particles attached to the inner wall of the respiratory tract, disturb the process of inhalation and exhalation and can also damage the lung tissue. The inner cell wall of the respiratory tract does not allow the entry of foreign particles (flour dust), flour dust cause irritation of the respiratory tract and hence cause various obstructive lung diseases.

Flour dust is an asthmagen causing sensitization of the airway in which the tract that enable air to pass into and out of the lungs periodically narrows, causing coughing, wheezing and shortness of breath. This narrowing is typically temporary and reversible, but in severe hypersensitivity reaction that may result in death. Study conducted by (Stobnicka et al., 2015) have shown that allergy symptoms of hypersensitivity reactions that include itching, sneezing, a stuffy nose, inflammation of the airways may occur with a resulting effect of wheezing (also known as asthma), allergic rhinitis, bronchial asthma and watery eyes. Other studies by (Ajeel et al., 2007) indicated that flour mill workers had work-related allergic symptoms.

8.1 Effect of flour dust exposure on respiratory symptoms

The finding from the present study suggests that exposure of flour dust in mill workers has resulted in higher percent prevalence of respiratory symptoms when compared to the controls.

The present study revealed that the prevalence of respiratory symptoms dry cough (27.7% vs. 9.3%), productive cough (11.1% vs. 5.6%), wheeze (14.8% vs. 3.7%), and breathlessness (16.6% vs. 7.4%) in flour mill workers and controls respectively. In this study, the higher prevalence of respiratory symptoms in flour mill workers may be due to prolonged exposure of flour dust, unhygienic conditions and poorly ventilated work places of the study areas as compared to the controls. A study by Wagh and colleagues (2006) found out that as compared to the non-exposed controls, flour mill workers had more respiratory symptoms like shortness of breath (42% vs. 16%), frequent coughing (34% vs. 8%), and respiratory tract irritation (19% vs. 5%).

Similar findings were reported in Egypt (Mohammadien et al., 2013) on the effects of exposure to flour dust on respiratory symptoms and lung function of bakery workers. The study showed that flour mill workers had cough, wheezing, and shortness of breath.
Another study in Khartoum (Sudan) also showed that daily work related respiratory symptoms were significantly increased in cases compared to controls (Ahmed et al., 2009).

Similar study conducted by Ghosh et al., (2014) on the prevalence of respiratory symptoms and disorders among rice mill workers develop disorders like phlegm (40.8 %), dyspnea (44.2 %), chest tightness (26.7 %), cough (21.7 %), and nose irritation(27.5 %).

The results of spirometry done by Melo et al., (2016) showed that two of 40 controls (5%) and 10 of 40 mill workers (25%) had lung function abnormalities. Thus, the flour mill workers lung abnormalities is five times more than the controls.

The present study investigated the prevalence and the type of pulmonary impairment observed among the flour mill workers. We found 27.7% (n=15) of the workers develop restrictive type of lung disorder while 11.1 %) (n=6) develop obstructive type of lung disease. On the other hand, there were only two subjects (3.7%) that showed an obstructive type of lung disorder . Hence, the prevalence of obstructive and restrictive lung diseases were higher in exposed group than in control group. The plausible explanation for the increased prevalence of restrictive lung impairment in exposed group is mainly due to flour dust that reacts with lymphoid and connective tissue in the terminal and respiratory bronchioles and interstitial inflammatory cells.

Similar study showed that workers exposed to flour dust have developed chronic bronchial irritation, which is responsible for the restrictive plus obstructive type of diseases. A study conduct by Nayak et al., (2013) showed that ventilatory impairments of lung function of flour mill workers were pure restriction (44%) and mixed type (56%).

Similarly, a study by Wagh et al., (2006) found that prevalence of Ventilatory impairment showed airflow obstruction (38% vs.16%) and restrictive defect (43% vs. 20%) in cases and in controls respectively. Nigsti (2014) also observed the adverse effects of exposure to wood dust may cause irritation of oral cavity and throat, tightness of the chest, irritant dermatitis, alveolitis, and deterioration of pulmonary functions.
8.2. Pulmonary function test

This study revealed that, all lung volumes and flow rates i.e., FVC, FEV_1, FEV_{1} \%, FEF_{25-75} \% and PEFR showed statistically significant reductions in the mean values in the flour mill workers as compared to their matched controls.

The findings of the present study are in lines with others Nayak et al. (2013) who reported a decrease in PEFR and association between duration of exposure and pulmonary function change. The longer summative time of exposure to flour dust was associated with reduced spirometric values compared to the controls (Zodpey and Tiwari, 1998).

Highly significant decrement in PEFR in flour mill workers may suggest the involvement and impairment of the larger airways. This may be due to irritative effect of flour dust causing hypertrophy of mucosal cells with increased secretion of mucous, a cause of obstruction to the exhaled air. PEFR is persistently low and represents collapsing of large airways.

A study by Awad et al. (1986) also observed a significant decline in the lung function parameters that include FVC and FEV_1, in workers exposed to flour dust compared to the control group suggesting that flour dust persistently affects the pulmonary function parameters.

The present study is also in consistent with other investigation that showed flour dust can adversely affects FVC, FEV_1, FEV_{1}\% (Meo, 2004).

We found significant negative correlation for FVC, FEV_1, PEFR and FEF_{25-75}\% and duration of flour dust exposure. This is in line with other findings that long-term exposure to flour dust decreased FVC, FEV_1, PEFR and FEF_{25-75}\% values (Nayak et al., 2013; Meo et al., 2005 and Hosseinzadeghi et al., 2013). Reduction in FEF_{25-75}\% value in exposed workers may be due to the obstructive pattern of the medium and smaller airways in the flour mill workers.

Similar studies conducted in Nigeria (Ijadunola et al., 2005) showed that flour millers recorded significantly lower mean lung functions compared with control subjects with an increased risk of developing abnormalities of lung functions and there is an association on the overall mean pulmonary function to the duration of exposure of the flour mill workers.
The present study is in line with a study (Wagh et al., 2006) who showed a decline in the FVC, FEV₁, and PEFR indices of the flour mill worker. Our findings are also similar to work done previously by Noor et al. (2000) who reported that prolonged and persistent exposure to spice dust worsen lung function of workers.

In Ethiopia, a study found a strong relationship between exposure to cotton dust in textile workers and byssinosis and other respiratory impairments. A study conducted by Alemu et al. (2010) and Woldeyohannes et al. (1991) showed statistically significant decrements in pulmonary indices of exposed subjects as compared to the means values of the observed and the predicted.

Studies on cement dust also showed that long-term exposure to dust of cement cause a declines in FEV₁ and FVC (Zeleke, 2011). Similar study by (Halemariam, 2013) states the maximum deterioration of lung function parameters has been observed in cobblestone workers.

The present study investigated the association between duration of exposure (in years) and different scores of pulmonary functions within exposed group. The results showed that the workers with less than 4 years of exposure had less but there is impairment in lung function as compared to time of exposure increased. However, workers exposed for 9 and more years showed a further reduction in pulmonary function. Similar study in India has shown the effect of flour dust and rice husk dust on pulmonary function. The study showed decrease in PEFR in rice mill workers that gradually becomes significant with increasing duration of exposure. Pulmonary function indices persistently decline in flour mill workers with more than 10 years of exposure compared to workers with 6-10 years of exposure (Dhillon et al., 2011).

There is no sufficient personal protective device in the work place and the workers do not wear the personal protective equipment professionally even if the material is available. Melo et al.,(2016) conducted similar study and found that thirty-three of 40 (82.5%) workers did not use a mask while working and 7 of 40 (17.5%) workers used a mask. Similar study by Nigsti (2014) and Temesigen (2015) showed that in wood chip factory and in petrol filling station workers do not wear personal protective equipment timely and there is not enough material in the working area.
9. Conclusions

- Occupational exposure to flour dust could cause respiratory irritation and sensitization.
- Flourmill workers showed significantly reduced in the pulmonary function tests (FVC, \( FEV_1 \), \( FEV_{1\%} \), PEFR and FEF\(_{25-75}\)) and lung efficiency due to excessive exposure to fine organic flour dust as compared to the controls.
- Percentage prevalence of respiratory symptoms were higher among exposed workers as compared to control groups and the difference was more vivid for dry cough.
- There is inverse relationship between duration of exposure and respiratory function. As the duration of exposure increases, there is a decrement of pulmonary function indices.
- Flour mill workers develop both restrictive and obstructive type of lung disorder.
- Personal protective devices were not available at work places and the workers usually do not wear even though the materials are available.
10. Limitations of the study

- The study failed to estimate the concentration of organic flour dust in the working area.
- Unable to determine sub-clinical cardio-pulmonary and other systemic disease that may affect the result of the study in both cases and controls.
11. Recommendations

✔ Stakeholders should implement the following important measures in order to achieve the standards of occupational health of flour mill workers.
  o Having well ventilated work areas,
  o Best engineering control measures,
  o Workplace hygiene,
  o Health education programs and
  o Protective measures such as wearing appropriate respiratory protective devices

✔ The ministry of health should issue detailed regulations that can be legally binding. There should be regular monitoring to ensure the implementation of these regulations.

✔ Health risk should be reduced by the mutual collaboration between health officials, mill managers and the workers.

✔ Further studies on the effect of flour dust in other systems (skin, Hearing loss and eye problem) should be conducted.
References


Arif Habib, Ayman johargy, Khalid Mahmood, Humma. (2014). Design and Determination of the Sample Size in Medical Research. IOSR Journal of Dental and Medical Sciences. 13, 21-31


Annex

Appendix 1: Questionnaire

I kindly request you to complete the following short questionnaire. It should take short time no more than 30 minutes. Your response is very important to me. Your willingness to participate and your cooperation are very important to the success this study. My requests to be answer the questions as frankly and accurately as possible. Your name remains anonymous and information you provide kept confidential.

Thank You in advance!

Code _________________No_________________

1 Socio demographic characteristics
Sex: Male ☐ Female ☐
Birth Date ____________________
Marital status ________________
Education status ______________
Monthly salary (birr) ____________

2. Occupational history
2.1 Do you work in flourmill? Yes ☐ No ☐
2.2 If yes to 2.1, how long you stay working in mill per day?
   A.8hr/day B. greater than 8hr/day C. less than 8hr/day
Have you ever worked for a year or more in any dust job other than the flour mill? Yes ☐ No ☐
If yes specify what kind of dust _________________________
2.3.1. Specify your job ________________________________
2.3.2 Total years worked ______________________________
2.4 Have you ever been exposed to flour dust in your work? A. Yes B. No
   If yes to specify what kind of flour dust _________________________
How long you have been working in the present work place. ________(years)

3 Known cases
a) Have you ever been known blood pressure? YES ☐ NO ☐
b) Have you ever been known diabetic? YES ☐ NO ☐
c) Have you ever been smoking? YES ☐ NO ☐

F) Do you make physical exercise such as weight lifting YES ☐ NO ☐

4 Dry Cough Related Questions

A. Do you usually have a cough? Yes ☐ No ☐
   If yes to question A:
   How many days per week do you cough ____________
   How many times per day do you cough? ____________
   At what time of the day do you have a cough?
   A. In the morning B. In the day, time C. At night D. If other specify ____________

B. Do you have a cough for 3 months or more in total during a year? YES ☐ NO ☐

C. For how many years you have had this Cough? ____________ (years)

5. Episodes cough with phlegm related questions

a) During the past three years, have you had any chest illness that has kept you from your usual activities for as much as a week? Yes ☐ No ☐

b) If yes to question a, have you have been, bring up more phlegm than usual in any of these illnesses. Yes ☐ No ☐

c) Do you usually bring up any phlegm from your chest during the day or at night?

d) How many days per week do you bring up phlegm? _______________

e) Do you have phlegm for 3 months or more in total during a year? YES ☐ NO ☐

6. Episodes of Breathlessness related questions

I. Are you breathless or troubled by shortness of breath when you walk and ascend a hill at an ordinary pace? YES ☐ NO ☐

II. If yes do you get shortness of breathing while you are walking with other people of your age on level ground? YES ☐ NO ☐

7. Episodes of wheeze related questions

   a) Have you ever had attacks of shortness of breath with wheezing? YES ☐ NO ☐
b) Do you wheeze in your chest? YES ☐ NO ☐

c) If you run, or climb mountains fast do you ever:
Cough? YES ☐ NO ☐
Get tight in the chest? YES ☐ NO ☐
Wheeze YES ☐ NO ☐

8 Past Illnesses “Any other problem related to your lung or respiration”

1. Attacks of chest trouble Yes ☐ No ☐
2. Any other chest illness Yes ☐ No ☐
3. Bronchitis Yes ☐ No ☐
4. Pneumonia Yes ☐ No ☐
5. Asthma Yes ☐ No ☐

9. Knowledge, attitude, practice (KAP) and awareness campaign of flour mill workers

1) Should mill workers wear protective and preventive equipment (PPE)? YES ☐ NO ☐
2) How often you wear PPE? A. Always  B. Occasionally  C. Never
3) Type of devices you use during your work hours (You may have more than one response. Encircle your responses) A. Mask  B. Respirator  C. Glove  D. Goggle  E. Safety shoes  F. covering nostrils  G. never
4) Do you know that exposure to flour dust can affect your health negatively? YES ☐ NO ☐
5) If you say yes for Q4, Which one of the following could be health effect of flour dusts? A. Lung and airways problems B. heart problem C. Skin diseases D. Eye problem and List if you know any others.
10. Questionnaire for Spirometric procedure

Code _____________ Number ______________

Date ______________

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<th>Minutes</th>
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Subject of Age in years, sex and anthropometric measurement of height and weight

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<th>sex</th>
<th>Age</th>
<th>Height in meter</th>
<th>Weight in Kg</th>
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PFTs

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<th>3rd trial</th>
<th>Best selected</th>
<th>% predicted</th>
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<td>FVC</td>
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<tr>
<td>FEV₁</td>
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<td>FEV₁/FVC%</td>
<td></td>
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<tr>
<td>PEFR</td>
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<tr>
<td>FEF₂₅-₇₅%</td>
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Type of respiratory disorder

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<tr>
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<th>Obstructive</th>
<th>Mixed</th>
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Once again thank you very Mach!!!!!!!!!!
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1. ወላጊ-

u) ወ-

v) ወ-

w) ወ-

x) ወ-

2. ወ-

u) ወ-

v) ወ-

w) ወ-

x) ወ-

48
ተ) ከአስራ ዓ-晶体 የልን ያሳማል? እም ዧልም ያለም

3 ከሆነ ከትመለከቱ

u) ዓ-晶体 የልን ከትመለከቱ? እም ያለም ያለምያም

v) ከሆነ ከም ከትመለከቱ? እም የልን ያለምያም


x) ከሆነ ከትመለከቱ ጋር ያለምያም

v) ከሆነ ከትመለከቱ ጋር ያለምያም ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያモン ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያモン ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያም ጋር ያለምያmonte
Appendix 2: Information Sheet

I am DESSALEGN DEMEKE. I came from Addis Ababa University; I am working my thesis for the partial fulfillment of a Master's Degree in Medical Physiology. You are asked to participate in a research study. Your participation in this study is voluntary if so, you would like to participate on this to fill the questionnaire and minor experimental procedures. This may take
up to 30 minutes. All information given you was kept confidential and disclosed only with your permission. You can choose to participate or not to participate in this study.

The study is designed to assess pulmonary function status in workers of flourmill in Addis Ababa, Ethiopia. To examine the extent of damage due to the effect of these flour dusts so that after completion of the study different recommendations will be made depending on the results and potential health risk of exposure to flour dust will be reported to Ministry of Labor and Social Affairs industrial bureau in Addis Ababa, Ethiopia.

If you have any uncertainty or question about the request you can contact the principal investigator or Research and Ethical Committee of Department of Physiology, Addis Ababa University

Investigator: Dessalegn Demeke

Mob +251-946 42 16 52, email dessal143@gmail.com

Addis Ababa University, Department of Physiology

Appendix 3: Consent Form

The investigator explains information about the study to me. I have the objective of this study to assess pulmonary function status in workers of flourmill in Addis Ababa, Ethiopia. I have been told that the study will help in better understanding of effect of flour dust on respiratory system.
In addition, I have been told about how the data collection is proceeding and the time it takes to complete the data collection. I also understood that the research imposes no risk and no composition would be provided to my family and me. I fill discomfort to respond to any of the question, I refuse or discontinue at any time as I wish to do so. I am assured that there will be confidentiality of my response. Therefore, I have now consented to participate in the study by signing this form.

Name of Subject______________________________________________

Signature of subject_________________________ date______________
ጥናቱ መስፋክር ነው በቀር ሁለ ከጤጠ ብ መረጃ ያስተናለስ፡፡ ይህ ግማት በአለታ የኅበላ መፋስትት ይህን ሀገር እር ከስረ ሁለ ከጤጠ ብ መረጃ ያስተናለስ፡፡ ለወሰን ያለው መረጃ ይህ ግማት በአለታ የኅበላ መፋስትት ይህን ሀገር እር ከስረ ሁለ ከጤጠ ብ መረጃ ያስተናለስ፡፡ ይህ ግማት በአለታ የኅበላ መፋስትት ይህን ሀገር እር ከስረ ሁለ ከጤጠ ብ መረጃ ያስተናለስ፡፡ ይህ ግማት በአለታ የኅበላ መፋስትት ይህን ሀገር እር ከስረ ሁለ ከጤጠ ብ መረጃ ያስተናለስ፡፡ ይህ ግማት በአለታ የኅበላ መፋስትት ይህን ሀገር እር ከስረ ሁለ ከጤጠ ብ መረጃ ያስተናለስ፡፡ ይህ ግማት በአለታ የኅበላ መፋስትት ይህን ሀገር እር ከስረ ሁለ ከጤጠ ብ መረጃ ያስተናለስ፡፡ ይህ ግማት በአለታ የኅበላ መፋስትት ይህን ሀገር እር ከስረ ሁለ ከጤጠ ብ መረጃ ያስተናለﺳ