EFFECTS OF OCCUPATIONAL EXPOSURE TO FLOUR DUST ON PULMONARY AND CARDIOVASCULAR VARIABLES IN LOCAL FLOUR MILL WORKERS IN IJEBU ODE LOCAL GOVERNMENT AREA OF OGUN STATE

S.O. Olalekan[1]*, I. O. Osonuga[1], O. A. Oyesola[1], E.O. Taiwo[1], M.M. Adeyanju[2], B. Tayo[3] and B.A. Olukade[1]
1 Department of Physiology, Olabisi Onabanjo University, Sagamu Campus, Sagamu, Ogun State, Nigeria.
2 Department of Biochemistry, Olabisi Onabanjo University, Sagamu Campus, Sagamu, Ogun State, Nigeria.
3 Department of Medical Microbiology and Parasitology, Babcock University Teaching Hospital, Ilishan, Ogun State. *Corresponding author: samuel.olalekan@oouagoiwoye.edu.ng

Received: December 13, 2021 Accepted: February 20, 2022

Abstract This study was conducted to establish the effects of flour dust on the lung functions and cardiovascular variables of local flour mill workers in Ijebu Ode Local Government Area of Ogun State, Nigeria. This study involved 35 local flour mill workers and matched controls. The subjects were matched for age, height, weight and socioeconomic status. The pulmonary function tests were done with a portable spirometer. The heart rate and blood pressure of subjects and controls were measured using a digital blood pressure monitor whereas the peripheral oxygen saturation was measured using a pulse oximeter. Independent T-test was used to test the differences in cardiopulmonary variables between the exposed flour mill workers and their matched controls. Regression analysis was used to investigate the effect of duration of exposure to flour dust on lung volumes. Significant reduction in the overall mean values of Forced Vital Capacity (FVC), Forced Expiratory Volume in 1 second (FEV_1), and Peak Expiratory Flow Rate (PEFR) was observed in the local flour mill workers relative to their matched controls; mean FVC was decreased in the exposed group (1.28±0.13L) when compared with control group (1.90±0.09L) ($p<0.001$), mean FEV_1 was significantly decreased when exposed group (0.99 ± 0.11L) was compared with the control group (1.553 ± 0.0636L) ($p<0.0001$), likewise the mean PEFR was significantly decreased when exposed group (2.09 ± 0.25L/min) was compared with the control group (3.88 ± 0.23L/min) ($p<0.001$). Heart rate was significantly increased when exposed group (86.71 ± 1.92) was compared with the control group (77.6 ± 1.48) ($p<0.001$); the systolic blood pressure was insignificantly increased when exposed group (138.7 ± 5.69) was compared with the control group (131.5 ± 2.642) ($p<0.208$), the Diastolic Blood Pressure was however significantly increased when exposed group (86.94 ± 2.77) was compared with the control group (79.86 ± 1.79) ($p<0.021$). Significant negative correlation for the r values were found when FVC, FEV_1 and PEFR were regressed on duration (in years) of exposure to flour dust. The FEV_1/FVC ratio of the exposed flour mill workers was on average of 80.5%. Significant reduction in FVC, FEV_1, PEFR and yet a normal FEV_1/FVC ratio is indicative of restrictive pattern of pulmonary disorder.
Keywords: Blood Pressure, Flour Dust, Pulmonary Function Tests, Spirometry

Introduction

Lung diseases can be grouped into obstructive, restrictive or combination forms. Spirometry is a common test used to assess how well your lungs work by measuring how much air you can inhale, how much you can exhale and how quickly you can exhale. Spirometry is useful in the diagnosis of these diseases and shows how restriction or obstruction affects pulmonary function (Meo & Al-Drees, 2005). Airborne particles may be inhaled through the nasal or oral route. Factors such as breathing rate, movement of air round the body etc, affects the quantity and level of assimilation of these particles. The inhaled particles may then either be deposited or exhaled again, depending on a whole range of physiological and particle-related factors. Sedimentation, a process whereby particles settle down and impaction, whereby the particles are packed together are the most important means whereby particles inhaled are deposited in various regions in the different regions of the respiratory tracts. (Lippmann, 1977).

Forced vital capacity (FVC) is the maximal volume of air that can be forcibly expelled from the lungs from a position of maximal inhalation. It indicates lung volume. Forced expiratory volume in 1 second (FEV_1) is the maximal volume of air exhaled in the first second of an FVC manoeuvre. In individuals with normal lung function this is 75–80% of FVC. FEV_1 reflects the mechanical properties of the large and medium sized airways. Forced expiratory ratio (FEV_1/FVC or FER%) is the ratio of FEV_1 to FVC, expressed as a percentage. This ratio is decreased in obstructive lung disorders and normal in restrictive lung disorders. In an adult, a normal FEV_1/FVC ratio is 70% to 80%. If restriction is suspected, further testing with static lung volumes may be required (Miranda, Brigitte and Matthew, 2011).

In Nigeria, various studies have shown the role of occupational exposure to environmental pollutants in the incidence of respiratory diseases in various occupational settings such as Ventilatory function of workers at Okpella cement factory in Nigeria by Alakija et al., (1990); Respiratory symptoms and ventilatory function of the saw millers in Ibadan, Nigeria by Ige and Onadeko (2000); An epidemiological study of the health status of sawmills workers in Benin City, Edo State, Nigeria by Okojie et al., (2003); Lung function status of workers exposed to wood dust in timber markets Calabar, Nigeria by Okwari et al., (2005); Pilot health survey among Enugu coal miners by Ogakwu, (1973) and pattern of disease and injury among road construction workers in Plateau and Bauchi areas Northern Nigeria by Jinadu, (1980), but very little attention has been paid to the health status of workers in the localized small scale flour processing industries.

The respiratory diseases caused as a result of exposure to flour dust are influenced by the chemical composition of the dust, the level of exposure and duration of exposure (Subbarao et al., 2009). The American Conference of Governmental Industrial Hygienists (ACGIH) defines flour as a complex organic dust consisting of wheat, rye, millet, barley, oats or corn cereal, or a combination of these, which have been processed or ground by milling (Karpinski, 2003). Flour dust is a respiratory sensitizer and as such can initiate reactions when exposed to the respiratory tract (Jeffrey et al., 1999; Mohammadien et al., 2013). Industries such as flour mills, cement plant and sawmills generate dust, which is diffused into the air and later inhaled (Abdulsalam et al., 2015).

Not much has been done on the effects of flour dust on pulmonary function and cardiovascular parameters of local flour mill workers in Nigeria. A very similar study done over 13 years ago reported on the respiratory effects of flour dust on flour mill workers on an industrial flour mill but did not investigate their pulmonary function parameters with respect to variation in the duration of exposure judging by the differences in the number of years spent at the flour mill. Though the study reported decline in pulmonary function tests of exposed groups when compared to control, it did not investigate if these declines have an effect on cardiovascular variables (i.e. blood pressure, heart rate and peripheral oxygen saturation) of the exposed group (Ijadunola et al., 2004). This study was therefore conducted to assess the impact of flour dust exposure on pulmonary function and cardiovascular parameters of local flour mill workers in Ijebu Ode Local Government Area of Ogun State, Nigeria.

Materials and Methods

An ex-post facto research design was used for this study. Thirty five (35) flour mill workers and thirty five (35) controls matched for age, height and weight took part in this research. The flour mill workers selected for this study formed the exposed group while the matched controls formed the control group. The subjects that formed exposed group were further divided based on duration of exposure to flour dust. The baseline measurements were taken, recorded and evaluated using independent t-test analysis, whereas the impact of duration of exposure on pulmonary function was analyzed using regression analysis.

Research Variables Measured

The variables measured were:- Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV_1), Peak Expiratory Flow Rate (PEFR); Peripheral Oxygen Saturation (SpO_2); Heart Rate (HR); Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP).

Criteria for Selection

The participants were both male and female local flour mill workers within Ijebu Ode Local Government Area of Ogun State, within the age range of 20-60 years, with unprotected exposure to flour dust on a daily basis.

Participants were found to be free from gross clinical abnormalities of the vertebral column, thoracic cage, neuromuscular diseases, known cases of gross anemia, diabetes mellitus, chronic bronchitis, emphysema, bronchial asthma, tuberculosis, ischemic heart diseases, malignancy, drug addiction, cigarette smoking and subjects who had undergone vigorous exercise, abdominal or chest surgery.

Exclusion Criteria

Subjects with gross clinical abnormalities of the vertebral column, thoracic cage, neuromuscular diseases, known cases of gross anemia, diabetes mellitus, chronic bronchitis, emphysema, bronchial asthma, tuberculosis, ischemic heart diseases, malignancy, drug addicts, cigarette smokers, tobacco chewers and subjects who had undergone vigorous exercise, abdominal or chest surgery were excluded from the study.

Inclusion Criteria

(1) Gender:- male and female.

(2) Age:- 20 to 60 yrs.

(3) Duration of work in Flour Mill:- at least 2 years.

(4) Absence of use of any protective equipment at working place.

Materials

The following instruments were used to collect data for this study.

Blood pressure monitor (Model: BSX500), Baseline pulse oximeter (Model: 12-1926), Portable Spirometer (CONTEC Sp10 Model), Nose Clip, Body Weighing Scale (Hanson Model RGZ-160) and Seca Height Scale.

Methods

- **Age:** The ages of the participants in the year as at last birthday was recorded.
- **Gender:** The genders of the participants were both male and female (and were represented as M and F).
- **Body Weight**: The participant's weight were measured with participants putting on light apparel and instructed to stand barefooted on the weighing scale looking straight ahead with both upper limbs by their sides. Zero error was eliminated by adjusting the control of the scale.
- **Height:** The participants were asked to take off their cap and shoes and stand erect on the base of the height meter, looking straight ahead with the heels together, knees extended and back against the height meter. Measurements were taken by bringing the horizontal bar of the height meter to touch the subject's vertex without undue pressure. The height was read off through the indicator and recorded.
- **Blood pressure:** On arrival at the venue of study, the subject were asked to sit down and thereafter the cuff of the digital blood pressure monitor was wrapped evenly and snugly around the left arm while the left arm freed from clothing of the participant above the site of the brachial artery, at the antecubital crease, is held at heart level, roughly at the junction of the 4th intercostals space with the sternum. The digital sphygmomanometer measured the blood pressure values and the heart rate which were duly recorded.
- **Measurement of the Pulmonary Variables:** For the FVC, FEV_1 and PEFR maneuver, subject's nose was clipped and instructed to take maximum deep inspiration as much as possible and hold it, then mouth piece was kept firmly in the mouth between lips so as to avoid escape of any air, then asked the subject to blow out forcefully and as fast and as long as much possible into the mouth piece and by doing this values of FVC, FEV_1 and PEFR were obtained and duly recorded.

Statistical analysis

The descriptive statistics of mean, standard deviation and inferential statistics was used for this study. Data after collection was grouped based on various hypotheses formulated for testing in this study, thereafter, the data were subjected to statistical tests. Independent T-test analysis was carried out with the aid of SPSS v. 20 while regression analysis was carried out with the aid of XLSTAT 2015 for Windows at 0.05 level of significance. The overall mean pulmonary function data were correlated against the duration of exposure. Linear regression was applied in the correlation of the relationship between duration of exposure and spirometric values and the equation $y = mx + c$ was derived with the correlation coefficient (r), where "y" means spirometric value, "m" stands for the slope of the graph, "x" indicates years of exposure and "c" is a constant. The r^2-value was used to determine the level of correlation significance.

Results and Discussion

This section gives the result of the analysis derived from this study.

Table 1: Demographic Characteristics of the study population.

Parameters		Mean± Std. Deviation	Sig. (2-tailed)
Age (year)	Exposed	49.03± 0.14	0.101
	Control	52.94± 1.77	
Height (m)	Exposed	1.53± 1.44	0.100
	Control	1.51± 1.23	
Weight (kg)	Exposed	68.829± 1.35	0.612
	Control	70.543± 2.78	

Significant ($p < 0.05$)

The result in Table 1 shows no significant outcome for age, height and weight (p=0.101, 0.100 and 0.612 respectively) between the exposed and control groups, hence we conclude that there is no significant difference between the two group in terms of age, height and weight.

Table 2: Pulmonary Function Tests of the Study Population.

Parameters		Mean± Std. Deviation	Sig. (2-tailed)
FVC (liters)	Exposed	1.28±0.77	0.000
	Control	1.90±0.53	
FEV_1 (liters)	Exposed	0.99±0.68	0.000
	Control	1.55±0.38	
PEFR (liters/min)	Exposed	2.09±1.47	0.000
	Control	3.88±1.36	

SPO2(%)	Exposed	97.09±1.93	0.550
	Control	97.31±1.16	
FEV_1/FVC	Exposed	0.81±0.19	0.501
	Control	0.84±0.15	

Significant ($p < 0.05$)

The result in Table 2 is on pulmonary variables of the study populations. The findings indicated that there is a significant reduction in the mean Forced Vital Capacity (FVC), Forced Expiratory Volume in 1 second (FEV_1) and Peak Expiratory Flow Rate (PEFR) ($p < 0.001$) when the exposed group was compared with the control group, hence the mean values of pulmonary functions test was significantly higher in the control group when compared with the exposed group. However there is no significant difference in the Peripheral Oxygen Saturation (SpO2) and FEV_1/FVC ratio ($p = 0.550$ and 0.501 respectively) between the exposed and control groups.

Table 3: Cardiovascular Parameters of the Study Population.

Parameters		Mean± Std. Deviation	Sig. (2-tailed)
Systolic Blood Pressure	Exposed	138.69±33.66	0.261
	Control	131.57± 15.63	
Diastolic Blood Pressure	Exposed	86.94±16.37	0.035
	Control	79.861±10.58	
Heart Rate	Exposed	86.71±11.34	0.000
	Control	77.60±8.75	

Significant ($p < 0.05$)

The result in Table 3 shows no significant difference in the Systolic Blood Pressure (SBP) ($p = 0.261$) between the exposed and control group. However, there is a significant difference in the Diastolic Blood Pressure (DBP) and Heart Rate ($p = 0.035$ and 0.000 respectively) between the exposed and control group, hence the mean values of Diastolic Blood Pressure and Heart rate was significantly higher in the exposed group than the control group.

Table 4: Regression analysis of the exposed groups on Forced Vital Capacity (FVC) based on duration (in years) of exposure.

FVC	R^2	Pr > F
Exposed Group	0.144	0.024

Equation of the model:

Y = -0.03564*X + 1.823

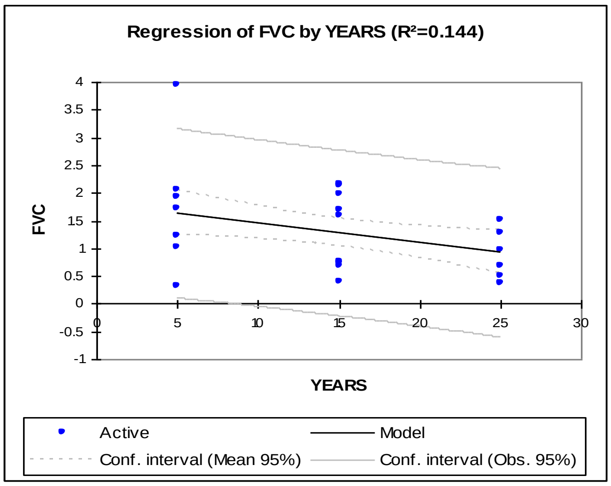

Fig. 1: Regression analysis of forced vital capacity (FVC) against the duration of exposure of the flour mill workers, a negative significant correlation was found, indicating that the increased duration of flour dust exposure decreased the FVC value

From Table 4, the probability corresponding to the F value is lower than 0.024, it can be concluded with confidence that there is a reduction in FVC values regressing on duration of exposure to flour dust. However, R^2 value of 0.144 indicates that only 14.4% variability in FVC values of the exposed group can be explained by the duration of exposure to flour dust.

Table 5: Regression analysis of the exposed groups on Forced Expiratory Volume in 1 second (FEV_1) based on duration (in years) of exposure.

FEV_1	R^2	Pr > F
Exposed Group	0.223	0.004

Equation of the model:

Y = -0.03901*X + 1.587

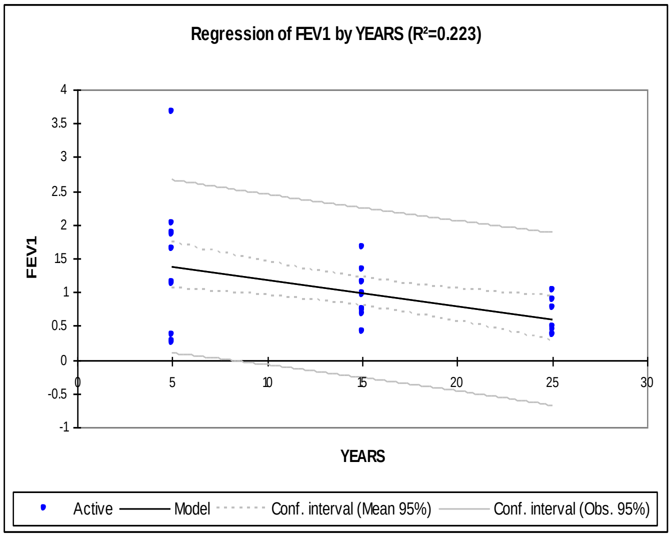

Fig. 2: Regression analysis of Forced Expiratory Volume in 1 second (FEV_1) against the duration of exposure of the flour mill workers, a negative significant correlation was found, indicating that the increased duration of flour dust exposure decreased the FEV_1 value.

From Table 5, the probability corresponding to the F value is lower than 0.004, it can be concluded with confidence that there is a reduction in FEV_1 values regressing on duration of exposure to flour dust. However, R^2 value of 0.223 indicates that only 23.3% variability in FEV_1 values of the exposed group can be explained by the duration of exposure to flour dust.

Table 6: Regression analysis of the exposed groups on Peak Expiratory Flow Rate (PEFR) based on duration (in years) of exposure.

PEFR	R^2	Pr > F
Exposed Group	0.272	0.001

Equation of the model:
$Y = -0.09329*X + 3.525$

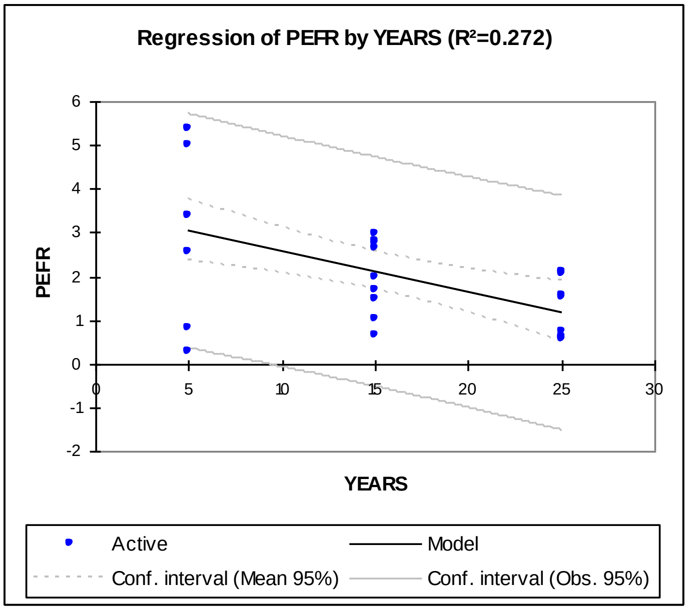

Fig. 3: Regression analysis of Peak Expiratory Flow Rate (PEFR) against the duration of exposure of the flour mill workers, a negative significant correlation was found, indicating that the increased duration of flour dust exposure decreased the PEFR value

From table 6, the probability corresponding to the F value is lower than 0.001, it can be concluded with confidence that there is a reduction in PEFR values regressing on duration of exposure to flour dust. However, R^2 value of 0.272 indicates that only 27.2% variability in PEFR values of the exposed group can be explained by the duration of exposure to flour dust. The findings of this study is similar with the findings of Ige and Awoyemi (2002) that investigated occupationally induced lung function impairment in bakery workers as a result of exposure to grain and flour dusts. They reported that the mean values of FVC, FEV_1, PEFR, and FEV_1/FVC% in the bakery workers were significantly lower than those of the control subjects. Zodpey and Tiwari, (1998) also reported that the PEFR value was significantly reduced in flour mill workers as compared to their controls. The decline in PEFR was linked with dust exposure and its duration. The present study confirms the findings of others and suggests that occupational exposure to flour dust could cause reduction in the pulmonary function parameters, such as FVC, FEV_1, and PEFR. Exposure to flour dusts in this study shows restrictive pattern of lungs disease as the FEV_1/FVC of the flour mill workers is normal (70 to 80% of FVC) but with reduced overall lungs functions of FVC, FEV_1 and PEFR when compared. The significant increase in Diastolic Blood Pressure coupled with a normal FEV_1/FVC ratio but reduced FVC and FEV_1 is suggestive of pneumoconiosis (a restrictive pulmonary disease) as also reported in Imaizumiet al., (2014). The Systolic Blood Pressure in this study however was increased insignificantly. The cardiovascular variability in Blood Pressure could be as a result of the inhibition of pulmonary stretch receptors which might have activated the sympathetic nervous system and resulted in exaggerated blood pressure variability. The present study revealed a dose response relationship between pulmonary function tests and duration of exposure to flour among the local flour mill workers.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

References

Abdulsalam ST, Abdus-salam IA., Moshood S & Arinde J 2015. Prevalence of Respiratory Symptoms and Lung Function of Flour Mill Workers in Ilorin, North Central Nigeria. International Journal of Research & Review, 2 (3), 55-66.

Alakija W, Iyawe VI, Jarikre LN & Chiwuzie JC 1990. Ventilatory function of workers at Okpella cement factory in Nigeria. West Afr. J. Med., 9(3): 187-91.

Ige OM & Awoyemi OB 2002. Respiratory symptoms and ventilator function of the bakery workers in Ibadan, Nigeria. West Afr. J. Med., 21 (4): 316–318.

Ige OM & Onadeko OB 2000. Respiratory symptoms and ventilatory function of the saw millers in

Ibadan, Nigeria. Afr. J. Med. Sci., 29 (2): 101–104.

Ijadunola KT, Erhabor GE, Onayade AA, Ijadunola MY, Fatusi AO, & Asuzu MC 2004. Pulmonary Functions of Wheat Flour Mill Workers and Controls in Ibadan, Nigeria. American Journal Of Industrial Medicine, 48: 308–317.

Imaizumi Y, Eguchi K, Taketomi A, Tsuchihashi T, Kario K 2014. Exaggerated blood pressure variability in patients with pneumoconiosis: a pilot study. Am J Hypertens., 27(12): 1456-63.

Jeffrey P, Griffin P, Gibson M, et al. 1999. Small bakeries – a cross-sectional study of respiratory symptoms, sensitization and dust exposure. Occup Med., 49(4): 237–241.

Jinadu MK 1980. Pattern of disease and injury among road construction workers in Plateau and Bauchi areas, Northern Nigeria. Ann Trop Para., 74(6): 578–584.

Karpinski EA 2003. Exposure to inhalable flour dust in Canadian flour mills. Appl. Occup. Environ. Hyg., 18: 1022–1030.

Lippmann M 1977. Regional deposition of particles in the human respiratory tract. In Lee DHK, Murphy S (editors), Handbook of Physiology: Section IV, Environmental Physiology, 2nd edition. Williams and Wilkins, Philadelphia. pp. 213-232.

Meo SA & AL-Dress AM 2005. Lung function among nonsmoking Wheat flour mill workers. Int. J. Occup. Med. Environ. Health, 18 (3): 246–251.

Miranda AP, Brigitte MB & Matthew TN 2011. Spirometry. Reprinted from Australian Family Physician, 40 (4), 216-219.

Mohammadien AM,. Hussein TM. & El-Sokkary, RT 2013. Effects of exposure to flour dust on symptoms and pulmonary function of mill workers. Egyptian Journal of Chest Diseases and Tuberculosis 62, 745–753.

Ogakwu MA 1973. Pilot health survey among Enugu coal miners. Niger Med. J , 3(2): 97–99.

Okojie OH, Egbagbe E & Kadiri I 2003. An epidemiological study of the health status of sawmills workers in Benin City, Edo State, Nigeria. J. Med. Biomed. Res.. J., 2 (1): 76-81.

Okwari OO, Antai AB, Owu DU, Peters EJ & Osim EE 2005. Lung function status of workers exposed to wood dust in timber markets Calabar, Nigeria. Afr. J. Med. Sc., 34: 141-45.

Subbarao P, Mandhane PJ & Sears MR 2009. Asthma: epidemiology, etiology and risk factors. CMAJ, 181, 181-190.

Zodpey SP & Tiwari RR 1998. Peak expiratory flow rate in flour mill workers, Indian J. Physiol. Pharmacol. 42 (4): 521–526.