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Oxygen Saturation Status and Prevalence of Respiratory Symptoms among Female Bakery Workers Using Fossil Fuel in Benin-City, Nigeria

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

Background: Flour dust is a respiratory sensitizer and chronic exposure to it and to Carbon Monoxide as a result of burning fossil fuel could affect the pulmonary functions and stimulate allergic responses. This study is designed to determine occupational related respiratory symptoms and oxygen saturation level of bakery worker exposed to flour dust.
Objective: Our objective is to compare the respiratory symptoms and oxygen saturation status of bakery workers with those of office workers not exposed to flour dust; compare dust concentration and carbon monoxide levels in the bakery and office environments.
Materials and Methods: Ninety healthy non-smoking adult female workers (test group) from 23 bread bakery industries participated in this study and age and sex matched with 90 healthy adult non-smoking female civil servants not exposed to such an occupational hazard were taken as controls. Pulse Oximetry was performed in all the participants who also completed questionnaire to assess demographic characteristics and prevalence of respiratory symptoms, The results were analyzed using Microsoft Excels, (2013) in percentages, mean ± standard error, student's t-test for

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cross group comparison and Chi-square test to assess the association between categorical variables.
Results: The study revealed that the mean oxygen saturation status (SpO_2) of bakery workers was significantly ($P < .05$) lower than that of the control group. Also, respiratory symptoms were found to be significantly more prevalent among bakery workers compared to the control group. Dust concentration and Carbon Monoxide (CO) levels were significantly higher in the baking environments compared with the control environments.
Conclusion: In conclusion, workers exposed to flour dust have sensitivity to allergens of flour protein and the risk of carbon monoxide poisoning which can lead to the increase in respiratory symptoms.

Keywords: Oxygen saturation; prevalence; respiratory symptoms; fossil fuel.

1. INTRODUCTION

1.1 Background of Study

In the baking industry, exposure to flour dust may cause respiratory illness of varying nature and severity, ranging from simple irritant symptoms to allergic rhinitis or occupational asthma (OA). Flour dust is a complex organic dust with varied composition including husk, cuticular hair, pollen, starch grains, bacteria and mucous spores [1]. Flour dust is a respiratory sensitizer and exposure to it could affect pulmonary function and stimulate allergic responses [2]. Wheat is the primary cereal grain used in bread making. This wheat flour contains starch and four different groups of proteins (water soluble albumins, globulins, prolamins (gliadin), and glutelins (glutenin)). Both gliadins and glutenins form viscous complexes, called gluten, which determine the structure and texture of bread to a great extent. The proteins present in flour dust are potential allergens. The flour dust in the baking industry may contain several other non-cereal components, called dough-improvers. These dough improvers include enzymes such as α-amylase of various origins, chemical ingredients (preservatives) flavourings, spices, and other additives (baker’s yeast). Sensitivity to one or more groups of these allergens can lead to an increase in the prevalence of respiratory symptoms as well as increase in reactivity of airways of workers. According to American Conference of Governmental Industrial Hygienists (ACGIH), flour proteins play a significant part in lung disease prevalence [3]. Studies have shown that flour dust exposure causes respiratory symptoms and the frequent pulmonary symptoms among bakers were sneezing, running nose, periodic breathlessness and chest tightness [4]. The occurrence of flour-related respiratory diseases depends on different factors, including air dust concentration, duration of exposure and other characteristic such as individual sensitivity and genetics [1].

Coal, wood, fuel oil, and natural gas are the major fossil fuels used by ovens. The combustion of these fossil fuels produces particulate matter (PM) emissions along with amounts of CO. Oxygen saturation is an indicator of the percentage of hemoglobin saturated with oxygen at the time of the measurement. Oxygen saturation values obtained from pulse Oximetry (SpO2) are one part of a complete assessment of the patient's oxygenation status however (SpO2) is not a substitute for measurement of arterial partial pressure of oxygen (PaO2,) or of ventilation.

In spite of the several reports on the effects of exposure to dust on lung function, there is however, no study on the prevalence of flour-related respiratory diseases and oxygen saturation status of bakery workers in Benin City, Nigeria. It was therefore the aim of this study to determine the associated respiratory symptoms and oxygen saturation level of bakery workers exposed to flour dust generated from baking ingredients in Benin, a capital city in South-South Nigeria.

2. MATERIALS AND METHODS

This is a comparative cross-sectional descriptive study. The study examined the prevalence of respiratory symptoms and oxygen saturation status of flour exposed workers, as test group and office workers, not exposed to flour dust as control group.

2.1 Sampling and Sample Size

Respondent-driven sampling (RDS) facilitated examination of populations through a chainreferral procedure in which participants recruit one another, akin to snowball sampling [5]. A total population of 180 made up of 90 female bread bakery workers (test) and 90 female office workers engaged in non-dusty occupations (control) were used for this study. To determine the sample size, the researcher used the formula for a comparative study [6].

2.2 Exclusion Criteria

Bakery workers and control group with skeletal abnormalities, neuromuscular diseases, and history of smoking, hypertension, drug addiction, tobacco chewers, family history of allergy and known cases of bronchiectasis or asthma were excluded from the study.

3. DATA COLLECTION

3.1 Ethical Approval

Ethical approval was obtained from the Ethical Committee of the College of Medical Sciences, University of Benin, Benin City. Written, informed and verbal consent were obtained from all participants.

3.2 Measurement of Height

The height was measured by the use of a stadiometer. The subjects were asked to stand without shoes and caps against a wall that is calibrated in metres and their heights taken.

3.3 Measurement of Weight

The weight was measured in kilograms using Avery scales (Avery Berkel, 2003 UK). The subjects were made to pull their shoes and drop any piece of items or objects in their possession. The subject was then asked to mount the scale and the weight read on the scale in kilograms.

3.4 Oxygen Saturation

Oxygen saturation (SpO2) values were obtained from Konica- Minolta Pulsox -300 pulse oximeter by Konica Minolta Sensing Incorporated, Japan. Normal value is 90% - 100%. The reading, obtained through pulse oximetry, used a light sensor containing two sources of light (red and infrared) that were absorbed by hemoglobin and transmitted through tissues to a photo-detector. The amount of light transmitted through the tissue is then converted to a digital value representing the percentage of hemoglobin saturated with oxygen.

3.5 Respiratory Symptoms

To estimate the prevalence of respiratory symptoms among participants and assess their demographic characteristics, all participants completed a researcher-made questionnaire made up to four parts:

- Demographic characteristics (age, weight, height, work experience and smoking history).
- Work history (considering all their activities during and after work shift).
- Medical history (history of cardiovascular and respiratory disease or seasonal allergy).
- The common respiratory symptoms based on the prevalent symptoms in backer's asthma (including coughing, sputum, shortness of breath, wheezing, rhinitis and respiratory track irritation).

3.6 Measurement of Dust Concentration

Measurement of dust (particulate matter 2.5 $\mu g/m^3$) ($PM_{2.5}$)concentration using a Microdust Pro real time dust monitor (Casella CEL-712 Microdust Pro 2010, USA) in the bakeries and offices of control subjects over an 8-hour period. Precise measuring of dust (particulate matter) concentration using the monitor "Microdust pro" is possible with the help of an optical device.

3.7 Measurement of Carbon Monoxide Level

The carbon monoxide levels of the environments were assessed using Extech digital carbon monoxide meter, battery powered with a Liquid Crystal Display (LCD) that displays results. The results were recorded every 15 minutes for 8 hours manually. Unit of measurement was parts per million (ppm).

3.8 Statistical Analyses

All the represented data were analyzed statistically by using MS-Excel, 2013. The data from this study was summarized using frequency count, percentages and descriptive statistics of mean ± SEM (standard error of mean). Values were compared using Student's t test and chi-square test ($\chi 2$) was used for qualitative data. Values were considered significant if $P \leq 0.05$.

4. RESULTS

The anthropometric measurements of the two groups, test and control are as shown in Table 1. There were no significant differences in the anthropometric parameters between the control and test subjects.

Table 1. Comparison of mean values of anthropometric in control and test groups

Parameters	Control N= (90) ± SEM	Test N= (90) ± SEM
Age (years)	35.5 ± 0.6	34.6 ± 0.56
Height (cm)	161.6 ± 0.98	162.9 ± 0.9
Weight (kg)	65.7 ± 1.07	66.1±1.49
BMI (kg/m²)	25.8 ± 0.5	24.9±0.45

BMI = Body mass index (kilograms per square meters)

As shown in Fig. 1, the mean value of dust concentration in the test environment was significantly higher than that in the control.

As shown in Fig. 2 showed the comparison of the mean values of Carbon Monoxide levels in control and exposed areas. It shows that carbon monoxide level in the test environments were significantly higher than that of the control.

The mean values of Oxygen saturation level in control and exposed participants as shown in Fig. 3. There was significant difference in the oxygen saturation level in control and exposed participants. The exposed group had significantly lower level of oxygen saturation compared to the control group.

As shown in Fig. 4, the nature of assigned job affected the level of SpO_2. The mixers/oven workers had the lowest SpO_2 level while the general duty staff had the highest level compared with the control.

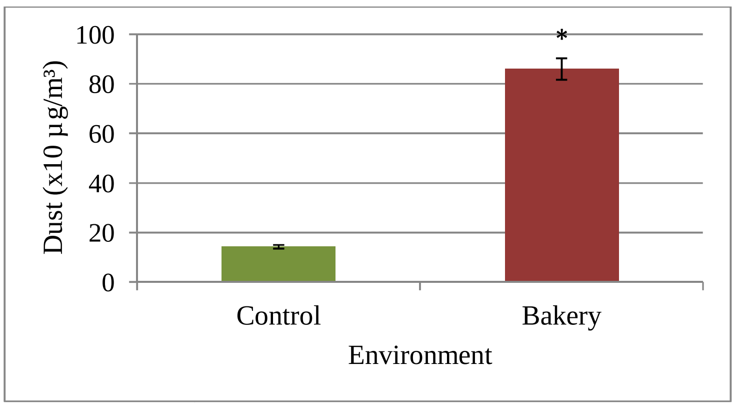

Fig. 1. Dust concentration ($PM_{2.5}$) in control and test areas

*N= (23) ± SEM *= p ≤ 0.05*

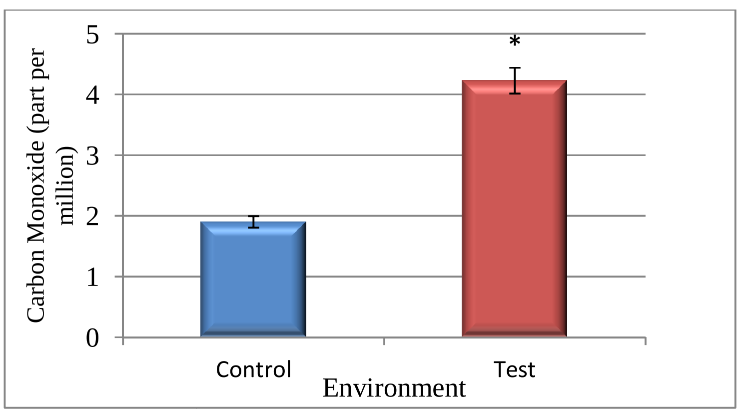

Fig. 2. Comparison of mean carbon monoxide levels in control and test environments

*N= (23) ± SEM * p = 0.05*

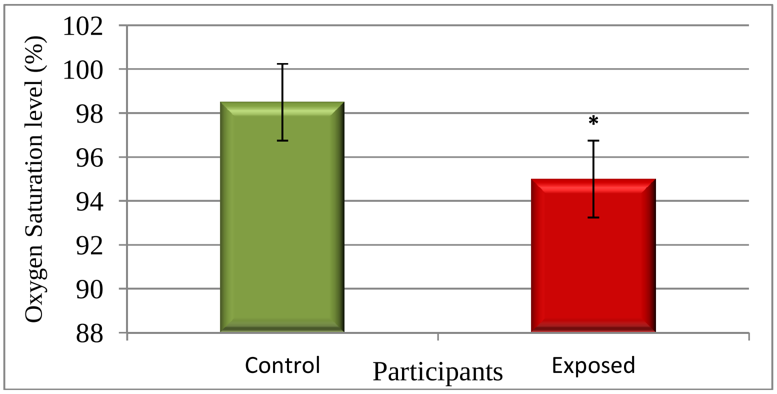

Fig. 3. Comparison of mean oxygen saturation level in control and exposed participants
*N= (180) ± SEM * P = 0.05*

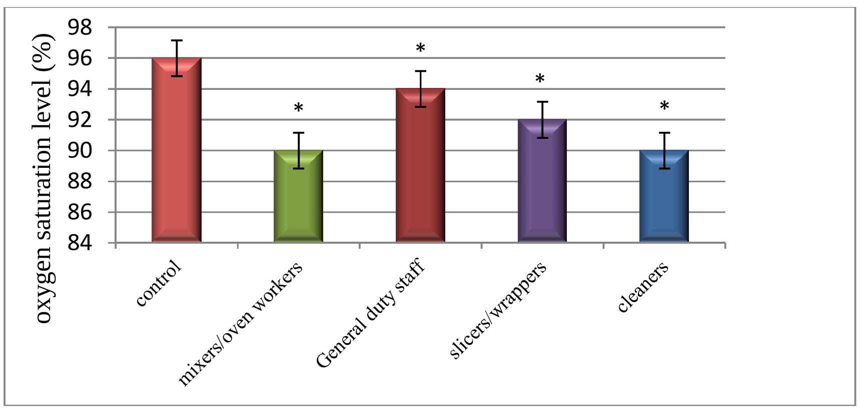

Fig. 4. Oxygen saturation (SpO_2) level in test and control subjects based on assigned duty
*N= (180) ± SEM * P < 0.05*

Prevalence of respiratory symptoms as shown in Table 2 revealed that all (test and control) manifested various degrees of respiratory symptoms. However, respiratory symptoms were found to be significantly more prevalent among bakery workers than the control group.

Table 2. Prevalence of respiratory symptoms among control and test subjects (%)

Symptoms	Control N=-90 (%)	Test N =90 (%)	p
Cough	5 (5.6)	68 (34)	.000*
Phlegm	1 (2.2)	36 (13)	.000*
Dyspnoea	8 (8.9)	24 (12)	.001*
Wheezing	4 (2)	28 (14)	.000*
Chest tightness	2 (1)	28 (14)	.000*
Sneezing	5 (5.6)	80 (40)	.000*
Running nose	4 (4.4)	70 (35)	.000*
Blocked nose	4 (4.4)	40 (20)	.002*

Notes: ***P** *< .05*

Prevalence of Respiratory Symptoms in test group in relation to job assignment as shown in Table 3, revealed that the mixers/oven workers manifested more respiratory symptoms, followed by those who participate in all assignments and cleaners. The slicers manifested the least respiratory symptoms.

5. DISCUSSION

One hundred and eighty female workers comprising of 90 bakery workers and 90 civil servants, age and sex matched control were the participants for this study. There was no significant difference between the mean weight, heights and body mass index (BMI) of test and the controls. Both groups have spent at least one year in bakery or as an office worker with a work hour of 6-10 hours five days a week.

In this study, the mean dust concentration within the bakery was significantly higher than that in

Table 3. Prevalence of respiratory symptoms in test group in relation to job assignment (%)

Symptoms	Mixer/oven workers N (%)	General duty N (%)	Slicers N (%)	Cleaners N (%)
Cough	18 (72)	25 (62.5)	5 (50)	4 (26.7)
Dyspnoea	15 (60)	20 (50)	5 (50)	8 (53.3)
Wheezing	20 (80)	28 (70)	6 (60)	4 (26.7)
Chest tightness	10 (40)	10 (25)	3 (30)	5 (33.3)
Running nose	22 (88)	30 (75)	5 (50)	5 (33.3)
Blocked nose	20 (80)	25 (62.5)	5 (50)	5 (33.3)
Sneezing	25 (100)	35 (87.5)	7 (70)	8 (53.3)

the control areas. The measured particles within the bakeries were far above the World Health Organization (WHO) statutory limits of 150 to 230 µg/m [3] respectively [7] (WHO, 2005).

It was reported twice that in Benue Cement Company, Nigeria that the highest concentration of suspended particle matter was recorded at the cement mill [8,9]. In another study carried out in flour mill, Ilorin, Nigeria, it was observed that the mean concentration of particulate matter (PM_{10}) in the production section was higher than that measured in the maintenance sections [10]. Dust and dusty environments are generated in the bakery and office environments however, the quantity of dust is more in the baking industries. These dusts are usually airborne contaminants which occur in gaseous form. Airborne dusts are of particular concern because they are well known to be associated with classical widespread Occupational Lung Diseases. Dust particles are usually in size range from about 1 to 100 nanometres (nm) in diameter and they settle slowly under the influence of gravity. The most appropriate measure of particle size for occupational hygiene situation is particle aerodynamic diameter which relates closely to the ability of the particle to penetrate and deposit in different sites of the respiratory tract. In this study, particle of aerodynamic size 2.5 µm was assessed. This size can penetrate the trachea, bronchioles and alveolar region of the lungs. Air Quality Index described these size of particles as fine respirable particulate matter, less than $1/20^{th}$ the width of the strand of hair [11].

The higher airborne dusts in the bakeries were generated from flour dust and fossil fuel during production processes. Flour dust is a complex organic dusts with varied composition such as husk, cuticular hair, pollen bacteria and mucous spores [1]. Flour dust is respiratory sensitizer [2] and exposure to it could affect the pulmonary function. Occupational Health and Safety Authority in its classification of respiratory sensitizing substances showed flour dust in the second place after isocyanides [12].

Carbon monoxide (CO) is a toxic gas emitted into the atmosphere as a result of combustion processes. CO is also formed by the oxidation of hydrocarbons and other organic compounds. It remains in the atmosphere for approximately one month before being oxidized to carbon dioxide. The bakeries used locally fabricated oven powered by charcoal and wood for generating heat during baking. The incomplete combustion of these fossil fuels (charcoal and wood) caused the release of carbon monoxide and other hydrocarbons. Although, the CO within control and test environments was within the WHO [7] recommended limit, the level of CO was significantly higher in the baking environment compared with the control environments. This may be attributed to incomplete combustion of fossil fuel used for baking. The low value recorded in the bakeries may be based on the fact that heating process is not continuous and some of carbon monoxide may have oxidized to carbon dioxide. Similar observation was made in Benue Cement Company, Nigeria where CO concentration was 1.25 ppm – 4.00 ppm [9]. Continuous exposure of CO can lead to hypoxia. CO binds strongly to hemoglobin in red blood corpuscles resulting in the production of carboxyhemoglobin (COHb). This impairs the transport of oxygen within the blood and can result in adverse effect on tissues with high oxygen needs such as the cardiovascular and nervous systems. High concentration (>1000 ppm) for prolonged hours (>8 hr) can give rise to hypoxia [13]. Studies have shown that carbon monoxide posed the largest risk for bronchiolitis among pollutants examined [14] and that CO level was found to have a stronger association with mortality than particulate matter [15].

The findings on dust concentration ($PM_{2.5}$) and carbon monoxide level suggest that the quality of air in the test (bakery) environment is lower than that of the control.

The study revealed that the mean oxygen saturation status (SpO_2) of bakery workers was significantly lower than that of the control group. SpO_2 reflects the level of oxygen in the blood. A similar study [16] on women sweeping the streets in Calabar did not show any significant difference compared with the control. It was found that increased exposure to air pollutant led to changes in SpO_2 which may reflect particle induced pulmonary or vascular responses [17]. Low oxygen saturation was independently associated with increased mortality caused by pulmonary diseases [18].

Our study demonstrated that job related respiratory symptoms such as cough, phlegm, productive cough, wheezing and dyspnea were more prevalent in the test group than the control. This finding is consistent with other observations which reported an increase in frequency of respiratory symptoms in a group of workers exposed to grain and flour dust [19,20]. Our study showed that regardless of exposure to relatively low concentration levels of inspirable flour dust, subjects working in the baking industry are at risk of developing respiratory symptoms. Thus, our findings provide evidence to further support the notion that exposure to flour dust is associated with a significant increase in the prevalence of respiratory symptoms.

Concerning the present study, the prevalence of respiratory symptoms may be explained by relatively prolonged exposure and poorly ventilated work places where the study was carried out. The flour dust particles easily enter the respiratory tract of an exposed person. These particles attach to the inner wall of the respiratory tract and disturb the process of inhalation and exhalation of air. The inner cell wall of the respiratory tract does not accept the foreign particles (flour dust), causing a slight irritation in the respiratory tract which is the primary symptom of respiratory disorder. These symptoms are protective reflexes derived primarily from airway receptors in the larynx, trachea and bronchi.

6. CONCLUSION

Occupational exposure to flour dust could cause pulmonary impairment. This is evidenced by the significant increase in the prevalence of respiratory symptoms and decrease oxygen saturation level between bakery and non-bakery workers. The findings are of importance in that they demonstrate the extensive need for preventive measures in the bakeries and other dust generating industries.

CONSENT

As per international standard or university standard, patient's written consent has been collected and preserved by the author.

ETHICAL APPROVAL

As per international standard or university standard, written approval of Ethics committee has been collected and preserved by the author.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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