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Analysis of Particulate Matter and Respiratory symptoms of Bakery Workers in a Tertiary Educational Institution South-South Nigeria

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Abstract:

One major factor causing deterioration of air quality adversely affecting human health is Particulate Matter (PM). PM is the sum of all solid and liquid particles suspended in air, which include organic and inorganic particles such as dust, soot, smoke, and liquid droplets. This is a comparative study of an institutional bakery and office workers of the same institution. The study compared the airborne particulate matter density of the sections and respiratory symptoms of the workers. The study group comprised of fifteen-(15) bakery workers (mixers, dough makers and bakers) exposed to flour dust who were engaged in various tasks in the baking process and fifteen-(15) control group of workers in administrative section of a department in the same institution. Data collected include measurement of dust using Microdust Pro real time dust monitor, laboratory result of dust done to elicit Polycyclic Aromatic Hydrocarbon (PAH) components and lung function tests. The results were statistically analyzed using software package IBM SPSS version 16. The study revealed significant higher dust concentration and PAH components in the bakery than the control area. In addition, the lung function results were significantly higher in the bakery workers than administrative staff. Clearly, the clinical significance of the results of this study is the observation that exposed bottling factory workers are at risk of developing respiratory symptoms and spirometric abnormalities.

Introduction

Air pollution has been a global environmental problem with the emergence of civilization [Lelieveldet al., 2015]. One major of the factor causing deterioration of air quality which adversely affect human health is Particulate matter. PM is the sum of all solid and liquid particles suspended in air, which include organic and inorganic particles such as dust, soot, smoke and liquid droplets.

According to the report by the World Health Organization (WHO) (2014), PM in outdoor air is responsible for about 4.5 million premature deaths every year and 10% of the total deaths on a global scale. According to [Stanaway et al., 2017], about 2 million of the 4.5 million deaths, representing 5% global total deaths, were the effects of PM directly on the respiratory system, particularly the lungs.

Wheat is the primary cereal grain used in baking industries and the dust described as a respiratory sensitizer, is a complex organic dust with varied composition including husk, cuticular hair, pollen, starch grains, bacteria and mucous spores (Meo and Drees; 2005).

PM is a major factors influencing deterioration of air quality, leading to adverse health effects on humans [Kim et al, 2015]. PM present in the air is classified base on the aerodynamic diameter which is the size of the particles. PM with a a size of 5-10 micron, ($PM_{5\text{-}10}\mu m$) is known as inhalable coarse particles and inhalable fine particles has a diameter of 2.5 micron($PM_{2.5}\mu m$) or less[Lee et al., 2015].PM with a diameter of 5–10 microns are deposited in the pharyngeal region, and ≤ 2.5micron in the trachea, bronchia and alveoliposing the greatest threat to health (Allen-Ramey et., 2005)

To protect public health, World Health Organization (WHO) prescribed standards for air quality. For outdoorair, WHO (2014) has strongly recommended emission rate target average for $PM_{2.5}$ and PM_{10}concentrations of 10 and 20 µg/m3,respectively annually, and 24-h average concentrations of 25 and 50 µg/m3, respectively. In Nigeria, the Federal Environmental Protection Agency (1991) sets a limit of 0.25mg/m3 as the threshold limit value for all nuisance particulates thought to be inert including flour dust.

Polycyclic Aromatic Hydrocarbons having not more than two aromatic rings, are present in PM. PAHs are organic chemicals emitted as a result of the incomplete combustion of various organic materials, such as the combustion of fossil fuels and biomass(Yang et al, 2021).

Prevalence of respiratory symptoms was higher in the study group with runny nose and sneezing 40.7%, cough 31.4%, sputum production 26.3%, chest tightness 22.9%, breathlessness 16.1%, wheeze 5.1% and asthma 5.1%. In the control group, prevalence of respiratory symptoms ranged between 0.8% and 5.1%.

Zhang (2020) posited that flour dust exposure is associated with a range of respiratory symptoms, including cough, wheeze, shortness of breath (dyspnea), asthma, eye problems, conjunctivitis, rhinitis, and sinusitis.

Also, Mohammadien et al, 2013) assess the impact of flour dust exposure on respiratory system and lung function of mill workers in Egypt and reported the prevalence of shortness of breath, wheezes and cough significantly higher in flour mill workers than controls ($p < 0.0001$).

Similarly, Aiguomudu, (2018), reported that respiratory symptoms, runny nose and sneezing, cough, sputum production, chest tightness, breathlessness, and wheezing were more prevalent in bakery workers than control in Nigeria. The author also reported that the difference between study and control groups respiratory symptoms prevalence was statistically significant ($P < 0.0001$).

In Iran, Hoseinzadeh et al., (2020) found that the density of respirable PM_5 was high in Saveh bakeries and workers were exposed to high levels of PM.

With the proliferation of fast food industries nationwide, creating an increased demand for flour and its finished products, this study is apt. Also, the exposure standards set for flour dust in Nigeria are not sufficiently protective in preventing sensitization have not been enforced due to lack of government commitment and the unavailability of manpower, this is significant to ensure environmental sustainability. The study is aimed at comparing the quality of air and respiratory status of bakery with non-bakery workers.

Materials and Methods

Study Setting

This was a comparative study conducted among bakery workers located within a Tertiary Institution in Benin, Edo State, Nigeria and office workers of same institution. In this bakery bread, pies and donut are processed using raw ingredients. There are three working zones in the factory, the loading section, mixing and baking sections. These areas are separated by few distances from one section to the other. The process of bakery involves loading the flour and other ingredients into a large wooden table by tipping them out of a bag. Then, all ingredients are mixed manually to prepare the dough. The dough is cut into different sizes of baking pan and transferred to the baking session. People working in this zone continuously add flour during mixture of the pastry. The baking section uses wood which emit carbon dioxide and smoke.

Population/Sample

This study consisted of two groups; a study and a control group. The study group comprised bakery workers (mixers, dough makers and bakers) exposed to flour dust who were engaged in various tasks in the baking process. The control group consisted of workers in administrative section of a department in the same institution as the bakery. All workers (n = 30), 15 from the three production zones and 15 administrative staff of same institution agreed to participate in the study and signed a consent form.
Ethics approval was obtained from the University of Benin Research Ethics Committee.

Methods of Data Collection

Demographic characteristics and the presence of respiratory symptoms for both bakery workers and controls data collected using a questionnaire. The questionnaire included occupational history, smoking history, respiratory symptoms, cough, sputum, wheezing and breathlessness. Presence of Cough and sputum was determined if the subject had the symptoms either during the day or at night for 5 or more days in a week. Breathlessness was considered to be present when the subjects complained of being short of breath when walking or climbing a flight of stairs. Chest tightness was described as feeling of fullness in the chest when at work. Wheeze was defined as hearing of

whistling sound when breathing. Symptoms were assessed whether they improved when away from work. Non-smokers were defined as subjects who had never smoked.

Dust Sampling

Airborne dust was measured using a Microdust Pro real time dust monitor (Casella CEL 712 Microduct Pro 2010, USA). Dust measurements were conducted on a randomly selected workday and when convenient for the company. In this study, particle of aerodynamic size 2.5 was assessed because this size of particle poses the greatest threat to health. The custom calibration was reused at all measurement sites. The Dust Track was set up at a height of ~1.5 m above the ground. The equipment was pre-recorded to take measurements every 30 minutes.

The dust collected was analyzed in the laboratory to elicit components. These measurements were all taken for three days in as the processes were being carried out. Dust sampling was only done in nine of the bakeries.

Measurement of Humidity and temperature

The humidity and temperature of the workplaces were measured using 1364 humidity-temperature meter, 2010, Taiwan.

Statistical Analysis

Data were coded and entered into a spreadsheet and analyzed using IBM SPSS (Statistical Package for Social Sciences) Statistics Version 20.96. Statistical level of significance was set at $p < 0.05$. Statistical comparison of means was done using the Student's t-test.

RESULTS

Sociodemographic Characteristics

Table 1 Socio-demographic characteristics.

Variable Age group	**Cases (n = 15)**	**Controls (n = 15)**	**p-Value**
20–29	3 (20)	2 (13.3)	0.655
30–39	9 (60)	7 (46.7)	
40–44	2 (133)	3 (20)	
45–49	1 (6.7)	3 (20)	
Mean ± SD age (years)	35.6 ± 6.2 years	36.4 ± 7.4 years	0.648
Sex			
Male	15 (100)	15 (100)	
Female	0 (0)	0 (0)	
Duration of Exposure			
1 – 3 years	8 (53.3)	4 (26.7)	
4 – 6 years	3 (20)	6 (40)	
7 – 9 years	4 (26.7)	5 (33.3)	
Mean ± SD exposure(years)			

5 ± 2.71years		
Smoking		
Yes	0 (0)	0 (0)
No	15 (100)	15 (100)

SD= Standard deviation; $p \leq 0.05$

As shown in Table 1, the mean age of the bakery workers was 35.6 ± 6.2years compared to 36.4 ± 7.4years among controls and no smokers among the cases or the controls. The mean duration of employment amongst bakery workers was 5.0 years with a range of 1–9 years

1. Quality of air in the bakery and control areas

Table 2: Environmental Assessment of the Bakery and Control areas

Components	**Case**	**Control**	**p-Value**
Temperature	68%	48%	0.03*****
Humidity	32ºC	24ºC	0/05*****
Dust Concentration	800µg/m³	10µg/m³	0.006*****
PAHs (ng/m³)			
Pyrene	130	0	0.000*****
Benzo(a)pyrene	110	5.2	0.002*****
Benzo(b)fluoranthrene	210	16	0.005*****
Total PAHs (x10ng/m³)	48.5	4.1	0.002*****

1. ºC = degree Centigrade; µg/m³ = microgram per cubic meter;
2. ng/m³ = nanogram per cubic meter; PAH = Polycyclic Aromatic Concentration

- = significance

Table 2 shows that temperature; humidity and dust concentration were significantly higher in the bakery environment than the control. Dust analysis revealed some Polycyclic Aromatic hydrocarbon components much higher in the bakery than control environment.

Table 3: Respiratory Symptoms among Bakery workers and Controls N = 30

Symptoms	**Bakery Workers N (%)**	**Control N (%)**	**p-Value**
Cough at work only	3(16.70)	1 (5.60)	0.603
Cough at night	1 (5.60)	0 (0.00)	1.000
Sputum production	1 (5.60)	0 (0.00)	1.000
Difficulty in breathing during the day or at night	2 (11.10)	0 (0.00)	0.486
Chest tightness in the past 3 months	4 (26.70)	0 (0.00)	0.055*
Catarrh (running nose) especially at work	13 (86.70)	0 (0.00)	0.004*
Frequent sneezing	8 (53.30)	1 (5.60)	0.006*
Feels better when off duty	11 (38.90)	0 (0.00)	0.008*
Wheeze in a smoky or dusty place	6 (33.30)	0 (0.00)	0.019*
Presence of at least one respiratory symptom	9 (50.00)	2 (11.1)	0.011*

- Multiple response question (Total number of responses > n or < n and percentages > 100% or < 100%);* = significant

As shown in Table 3 the frequency of respiratory symptoms among bakery workers and controls. Clearly, the frequency of respiratory symptoms was higher among bakery workers than controls. Overall, the result was statistically significant in the variables of wheeze in a smoky or dusty environment, presence of at least one respiratory symptom, better symptoms at weekends and better symptoms during holidays ($p < 0.05$). In particular, 6 (33.3%) exposed workers had wheeze in a smoky or dusty environment, 9 (50.0%) exposed workers reported at least one respiratory symptom compared with 2 (11.1%) of controls, 5 (27.8%) had better symptoms at weekends, and 7 (38.9%) had better symptoms at holidays ($p < 0.05$). Generally, the most reported respiratory symptoms among exposed workers were cough (22.2%), sputum production (5.6%), breathlessness (11.1%) and wheeze (44.4%).

Discussion

This comparative study assessed the work environment and respiratory health status of bakery workers and administrative staff of same institution. The bakery can be classified as traditional with two major sections; processing and sales sections. The data showed that workers and controls were comparable in age (35.6 vs. 36.4 years), the study setting and small sample size did not allow for match generalizability. Average duration of employment of workers was 10 years, with a range of1–9 years, which suggest that the workers had worked long enough for sufficient exposure.

In this study, the mean dust concentration within the bakery was significantly higher than that in the control area. Previous studies conducted in Nigeria gave similar results. Abdulsalam et al, (2015) reported higher mean dust concentration in production than maintenance sections of flour mill in Ilorin, Nigeria. Similarly, Agbazua, (2013) reported high concentration of dust in Benue Cement Factor, Nigeria. Also, the dust concentration within the bakery was above the Federal Ministry of Environment and World Health Organization statutory limits of 250µg/m^3 and 150 - 230µg/m^3 respectively. Higher dust in the bakery is generated from flour dust and fossil fuel during production in particular.

Two climatic factors, relative humidity and temperature of the environments, were assessed. The results revealed that values of relative humidity and temperature within the bakery were significantly higher than that of the control. Litvak et al, (2001) posited that low relative humidity enhances deposition of dust. This assertion is at variance with the findings of high relative humidity and dust concentration in this study. Poor ventilation, as observed in the bakery may have contributed to the high value of relative humidity and dust concentration. Miguel et al, (2004) in their study on aerosol particle deposition and distribution in bifurcating ventilation ducts reported that high relative humidity with poor vemntilation enhance deposition of particulate matter. In Iran, Mirmohammadi (2013) reported that relative humidity was high in an indoor air quality assessment of traditional bakeries. The processes of baking generate a lot of heat consequently, high temperature as reported in this study. Similar finding was revealed by Jayamuragan (2011) in Iran.

Also in this study, dust analysis revealed that total polycyclic aromatic hydrocarbon (PAHs) was significantly higher in the bakery compared with the control. This result affirms the findings of Ibhazehiebor et al, (2010) and Zhang &Tao, (2009) that PAHs are released during industrial activities and cooking processes such as baking frying smoking etc. This study found three PAHs compounds, Benzo (a) pyrene (BaP), Benzo (b) fluoranthene, Pyrene in the bakery environment and two, Benzo (a) pyrene (BaP), Benzo (b) fluoranthene in the control area. In laboratory studies, animals exposed to certain levels of some PAHs over a long time have suffered lung cancer from inhalation of the

substance (Latif et al, 2010; Lynch & Rebbeck, 2013). Therefore prolong exposure of bakery workers may lead to cancer of the lungs.

The results of this study also showed that bakery workers had a significantly higher prevalence of respiratory symptoms compared to controls. This may be due to the irritant effect of inhaled flour dust on the workers, poor ventilation in the production area and the lack of effective personal protective equipment. Awopeju et al. (2017) have shown that fume inhalation caused significantly high erodds of respiratory symptoms among a subset of female street cooks in Nigeria. The most reported symptoms among the study group were runny nose and sneezing, followed by cough and sputum production. In comparison, fewer workers in the control group had these symptoms. The difference in the prevalence of these symptoms between study and control group was statistically significant ($p<0.0001$). This is consistent with a study in Ibadan, Nigeria where the most prevalent symptom among bakery workers was also sneezing and runny nose. This can be explained by the irritant nature of flour dust which tends to give rise to short term nasal symptoms such as sneezing and rhinorrhea.3 Similarly, a study in Egypt found a statistically significant higher prevalence of cough, shortness of breath, wheeze and asthma among flour mill workers than controls (Mohammadien, et al, 2013).

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