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OCCUPATIONAL EXPOSURE TO WOOD DUST AND PREVALENCE OF RESPIRATORY HEALTH ISSUES AMONG SAWMILL WORKERS IN ABEOKUTA METROPOLIS, OGUN STATE, NIGERIA

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ABSTRACT

Wood dust is regarded as a possible occupational cancer-causing substance that negatively impacts human respiratory organs. This study investigated wood dust concentrations at sawmills and decline in pulmonary function among occupationally-exposed workers in Abeokuta Metropolis, Ogun State. A comparative cross-sectional study was carried out among 315 randomly selected sawmill workers (SW) in 11 sawmills and 100 non-sawmill workers (C) using a structured questionnaire and a spirometry test of lung function. Dust monitoring in sawmill and control locations was carried out using the portable Beckman Counter. Lung function test was performed using a spirometer. Data were analyzed for descriptive and inferential statistics. The mean concentrations for Particulate Matters: $PM_{2.5}$ − particles with aerodynamic size less than 2.5 microns (53.1±0.60) and PM_{10}− particles with aerodynamic size less than 10 microns(101±0.47) were higher than the WHO guideline limits of 25 and 50 µg m^{-3}. The body mass index (BMI) of SW was 26.7 (overweight) while that of C was 24.5 (healthy). Prevalent respiratory symptoms include sneeze (12.7%), running nose (10.8%), eye irritation (10.8%), cough (6.3%), chest pain (6.3%), skin irritation (5.4%), chest tightness (5.1%) and phlegm (5.1%).Lung function parameters of SW showed Peak Expiratory Flow Rate (PEFR), Forced Expiratory Volume (FEV_1), Forced Vital Capacity (FVC), and ratio of FEV_1 to FVC (FEV_1%) to be 2.85, 0.95, 1.44, and 66.2, respectively, which were significantly lower than in the control group (PEFR= 3.55, FEV_1= 1.11, FVC= 1.57 and FEV_1%= 74.6). Analysis of variance of lung function between the SW and the C-group showed significant ($p<0.05$) differences between the mean of PEFR, FEV_1% and FEV_1 for both groups, except for FVC ($p = 0.269$). A significant negative correlation was found between SW exposure to wood dust and lung function parameters: PEFR ($r = -0.121$; $p<0.05$), FEV_1% ($r = -0.121$; $p<0.05$), and FEV_1 ($r = -0.105$; $p<0.05$), FVC ($r = -0.054$; $p<0.05$). This study demonstrated that, in comparison to the control group, sawmill workers in Abeokuta were more susceptible to environmental pollution and the hazards associated with wood dust; had a higher prevalence of respiratory and pulmonary-related symptoms; had decreased pulmonary functions; and had BMI values that were higher than the recommended guideline values.

Keywords: Abeokuta, Lung Function, Particulate Matter, Sawmill Workers, Spirometry.

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INTRODUCTION

Wood is one of the forest resources and the most multipurpose raw material the world has ever known (Sekumade *et al.,* 2011).

Wood is a complex bio-chemical material often used to build a product, which creates a variety of hazards due to release of wood dust from the industrial, construction and demolition activities (Owoyemi *et al.,* 2016). Wood dust is produced when machines or tools are used to process wood and is mainly a by-product of the process, not produced for any definite purpose (Mohan *et al.,* 2013). Major wood processing factories in Nigeria include sawmills, plywood mill, pulp and paper mills and other small-scale wood product manufacturing companies, furniture, carpentry and cabinet makers (Ogunwusi and Jolaoso, 2012). Sawmills account for over 93% of the entire wood processing industries in Nigeria (Ogunwusi, 2014). It is estimated that at least 2 million people are exposed to the noxious effect of wood dust worldwide (WHO, 1997).Some factors have been reported to enhance exposure to wood dust at sawmills, which include, the nature of the working environment, use of obsolete machines, absence or poor installation of dust control devices and inadequate maintenance of ventilation systems (Mandryk*et al.,* 2000).

The National Institute of Occupational Health and Safety (NIOSH) in USA recommends that wood dust concentration should not exceed 1 mg/m^3 in the working atmosphere for an 8-hour working period (NIOSH, 1998). The American Conference of Governmental Industrial Hygienists (ACGIH) recommends 8-hour threshold limit value (TLV) of 1 mg/m^3 for certain hardwoods and 5 mg/m^3 for softwood (ACGIH, 2022). The Occupational Health and Safety Administration (OSHA) also recommends 3mg m^{-3}for hardwood dust and 5mg m^{-3}for softwood dust as work exposure limit for workers in the wood processing industry based on an 8-hour time-weighted average (Health and Safety Executive (HSE), 2022).

Occupational exposure to wood dust may subject sawmill workers to risk of respiratory infections, diseases, injury and accidents in their workplace (Mijinyawa and Bello, 2010). Wood dust contains some other agents which have been reported to contribute immensely to the prevalence of respiratory health effects among sawmill workers. Such agents include endotoxin, gram-negative bacteria, fungi and β-D-glucan. Any contact to these agents by sawmill workers can result in organic dust toxic syndrome, upper respiratory tract toxicities, and extrinsic allergic alveolitis (Eduard *et al.,* 1993; Mandryk*et al.,* 2000; Prazmo*et al.,* 2000).

Many studies acknowledged that exposure to wood dust in sawmills were connected to a rise in prevalence of respiratory symptoms: asthma, phlegm, wheeze and cough symptoms and eye and nose irritation (Douwes *et al.,* 2000;Osuchukwu*et al.,*2013; Mahmood *et al.,*2015; Tobin *et al.,* 2016) and a decrease in lung function capacity as evident by reduced peak expiratory flow rate (PEFR), forced vital capacity (FVC), and forced expiratory (FEV_1) volume (Osman and Pala, 2009; Ennin *et al.,* 2015; Tobin *et al.,* 2016). Also, the modes of treatment of wood wastes, particularly open burning could pose grave dangers to human and environmental health (Osman and Pala, 2009; Oguntoke *et al.,* 2013; Mahmood *et al.,* 2015; Olujimi *et al.,* 2016).

In addition to this, there is less published data on the quantification of particulate dust concentration in sawmills as an index of exposure and prevalence of respiratory symptoms and pulmonary function decline associated with wood dust exposure among

sawmill workers at the national or regional level in the face of an ever-increasing number of sawmills operating within Nigeria below ideal conditions. The state of health and safety of sawmill workers in Nigeria is not receiving the needed attention from the relevant Government Health Departments and Agencies. The present study was designed to evaluate the concentration of particulate matter in sawmills and to investigate prevalence of respiratory symptoms and pulmonary function status among sawmill workers within Abeokuta Metropolis, Ogun State. This study is in line with the Goal 3 (Good health and well-being) and Goal 7 (Affordable and clear energy) of the Sustainable Development Goals of the United Nations (SDGs, 2015).

MATERIALS AND METHODS

Study design

The study adopted a cross-sectional comparative design, which involved an assessment of lung function and the respiratory system among sawmill workers in Abeokuta as subjects and non-sawmill workers as controls.

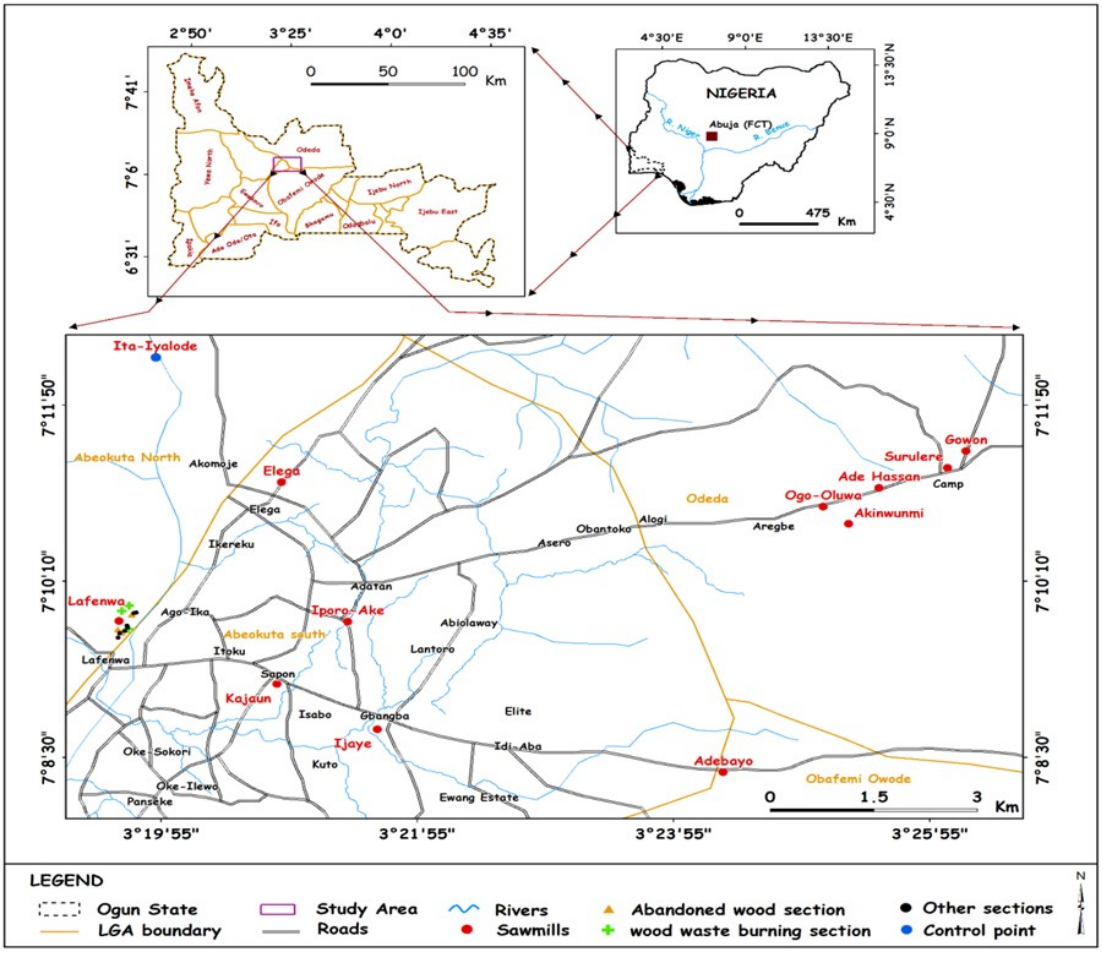

Figure 1. Location of Sawmills in Abeokuta, Ogun State, Nigeria

Study locations

The study was conducted in Abeokuta Metropolis, Ogun State. It traversed Abeokuta North, Abeokuta South, Odeda and Obafemi/Owode Local Government Areas (LGAs) with a land area of 1256 km^2. The study areas have an estimated population of 1,104,000 inhabitants in 2016 (National Population Commission, 2016). The city region is located on Latitude 7°11'–7^o 8' N and Longitude 3°19'–3^o 25' E (Fig. 1). In 2018, about 23 active sawmills were enumerated in the metropolis.The sale of timber in sawmills in the city promotes socio-economic development in terms of job creation, human welfare improvement, and export earnings (Akande, 2005).

Study population

Participants selected for this study were sawmill workers and non-sawmill workers in Abeokuta. The control (Non-sawmill workers) group recruited for this study consisted of civil servants, University graduates, artisans and traders.

The inclusion criterion for sawmill workers was that he or she must have been involved in wood processing in one of the selected sawmills at least for a year.

The exclusion criterion for a non-sawmill worker was that he or she must not have a history of working in any sawmill, but must have been living in Abeokuta at least for a year.

Sample size determination

The sample size for this study was determined using the mathematical approach by Miller and Brewer(2003).Determination of sample size was based on the estimated total population of the sawmill workers in Abeokuta Metropolis (N=2300).

$n = [N / 1+N (e)^2]$

Where:

n – Desired sample size

N- The population size

e- The desired level of precision or level of acceptable error = 0.05)

Total sample size (n) = $[2300/ (1+2300 (0.05)^2] = [2300/ (1 + 2300 \times .0025)]$

$= [2300/6.75]$

$= 340.7407$

$= 341$

Based on the above calculation, the appropriate sample size for this study was 341.

Sampling Procedure

Multi-Stage random sampling procedure was employed and the procedure is described as follows:

Stage 1: The study sites in Abeokuta Metropolis traversed four Local Government Areas in Ogun State (Abeokuta South; Abeokuta North; Odeda and Obafemi /Owode).

Stage 2: Eleven sawmills, which constituted approximately 48% of those located within the metropolis, were randomly selected for study. These were Lafenwa, Elega (Abeokuta north LGA),

Stage 3: Workers who were at the risk of occupational exposure to wood dust daily in their workplace were selected at random within various sections connected with wood processing. Only those who gave their consent to take part in the study were interviewed and their lung function assessed.

Data Collection

Survey based on questionnaire administration to respondents.

A structured questionnaire consisting of 21 items was administered to respondents in the study area. Three hundred and Fifteen Sawmill workers and 100 Controls that successfully completed and returned the questionnaire were enlisted for the lung function test, while 45 selected respondents who did not return their questionnaire were excluded from the lung function test. The questionnaire comprised of three sections (A-C) on socio-demographic data, workers' awareness level of the risk factors associated with dust exposure in their workplaces, duration of dust exposure hazard among the sawmill workers, the respiratory ailments experienced, the use of personal protective equipment (PPE) and the wood dust management style adopted respectively (Medical Research Council Committee (MRCC), 1960). The study was carried out between June and December 2018.

Sampling of particulate matter in sawmills

Dust monitoring in sawmill and control locations was carried out using the portable Beckman Counter (HHPC6+/3+/2+). The Total Suspended Particulate (TSP) and Particulate Matters ($PM_{2.5}$ –particles with aerodynamic size less than 2.5 microns, and PM_{10}– particles with aerodynamic size less than 10 microns)were measured at the Lafenwa Sawmill Complex and Ita-Iyalode (about 2 km to the Lafenwa Sawmill, as control site) in Abeokuta. Eight different sawmill sections (two sections per week for 2 months) and the control site (once in a month for 2 months) were monitored with the aid of gravimetric sampler from 10.00 am to 6.00 pm (working period for sawmills). The instrument was switched on in the morning, allowed to stabilize and then calibrated according to the manufacturer manual. The equipment was placed at about 3 feet from the sampling location to draw PM into the sampler, using the probe. The concentrations of TSP,$PM_{2.5}$ and PM_{10} were displayed on the screen and recorded in line with the methods of Tobin *et al.* (2016). GPS (Garmin® 12) was used to take the coordinates of each of the sampling location.

Spirometry measurement of respondents

Spirometry examination was performed using a calibrated Contec™ digital spirometer (model SP10) to assess the lung function of the sawmill workers and the control. The device was calibrated daily and all measurements were corrected for body temperature, pressure and saturation (Altalag *et al.,* 2009). Spirometric testing was carried out from Wednesday to Friday between the hours of 10:00 am and 6.00 pm, during which time was anticipated that the sawmill workers had been reasonably exposed to wood dust. Spirometry was done on participants in a standing position tightly holding their nose with the first duo fingers. Each subject was made to complete a dynamic spirometry examination with at least three acceptable and two reproducible maneuvers according to the test procedure of the European Respiratory Society (Altalag *et al.,* 2009).The largest FVC and FEV_1 values from all acceptable spirometric curves were reported. FEV_1/FVC ratio was measured using the absolute values of FEV_1/FVC for each respondent to arrive at final spirometry test.

Anthropometric Parameters of the respondents.

The respondents' height and weight were measured using a meter rule and a weighing scale. These parameters helped to determine

the body mass index (BMI) of the subjects and the control group.

Statistical Analysis

Data collected on demography and medical status of the workers, risk factors and particulate matter concentration were collated and analyzed using descriptive (frequency distribution, sample means and percentages), and inferential (t-test, Analysis of variance (ANOVA) and Pearson Correlation) statistics through the SPSS for windows (Version 21.0). T-test was used to test the significance of difference between subject and control mean values. Analysis of variance (ANOVA) was used to show the observed differences between the mean values of PEFR, FEV_1% and FEV_1 for SW and control. Statistical significance was set at $p<0.05$ for all values.

Ethical Considerations

Ethical approval for the study was obtained from the Federal Medical Centre Idi-Aba, Abeokuta, Ogun State, Nigeria before the commencement of the study. The ethical approval number was FMCA/470/HREC/03/2018/11.

RESULTS

Socio-demographic characteristics of Respondents.

Of the 315 sawmill workers, 61.3% were males and 38.7% were females (Fig. 2). The control showed that 73% were males and 27% were females. The age group with highest percentage was 37-47 years which accounted for 38.7% and 33.0% in subjects and control, respectively. The mean ages of sawmill workers and non-sawmill workers were 40.82±10.48 and 35.42±11.53, respectively. Mean height and weight of subjects were 164.4±8.42 and 72.3±14.41 (with body mass index, BMI of 26.7), while that of control were 162.9±7.63 and 64.9±9.96 (with BMI of 24.5). Also, 8.6% of the subjects and 39.0% of the control had tertiary education. Sawmill workers and Controls (21.3% and 25.0%) earned a monthly income of N20, 000 and above (Fig. 2).

Working conditions and safety issues of sawmill workers at workplace.

Most of the sawmill workers were Plank Sellers (54.0%), while the wood drawers were the least category (0.3%) among sawmill workers (Table 1). About half of the sawmill workers (49.8%) had worked in the sawmill industry for more than 15 years and 83.8% of them worked for more than 8 hours daily. Also, 97.1% of the sawmill workers did not use personal protective equipment (PPE) while working in sawmills. Majority of the sawmill workers (55.6%) discarded wood waste by burning, while 4.4% employed evacuation strategy. Only 5.7% of the exposed workers engaged in health insurance scheme which is not readily made available to workers in Nigeria (Table 1).

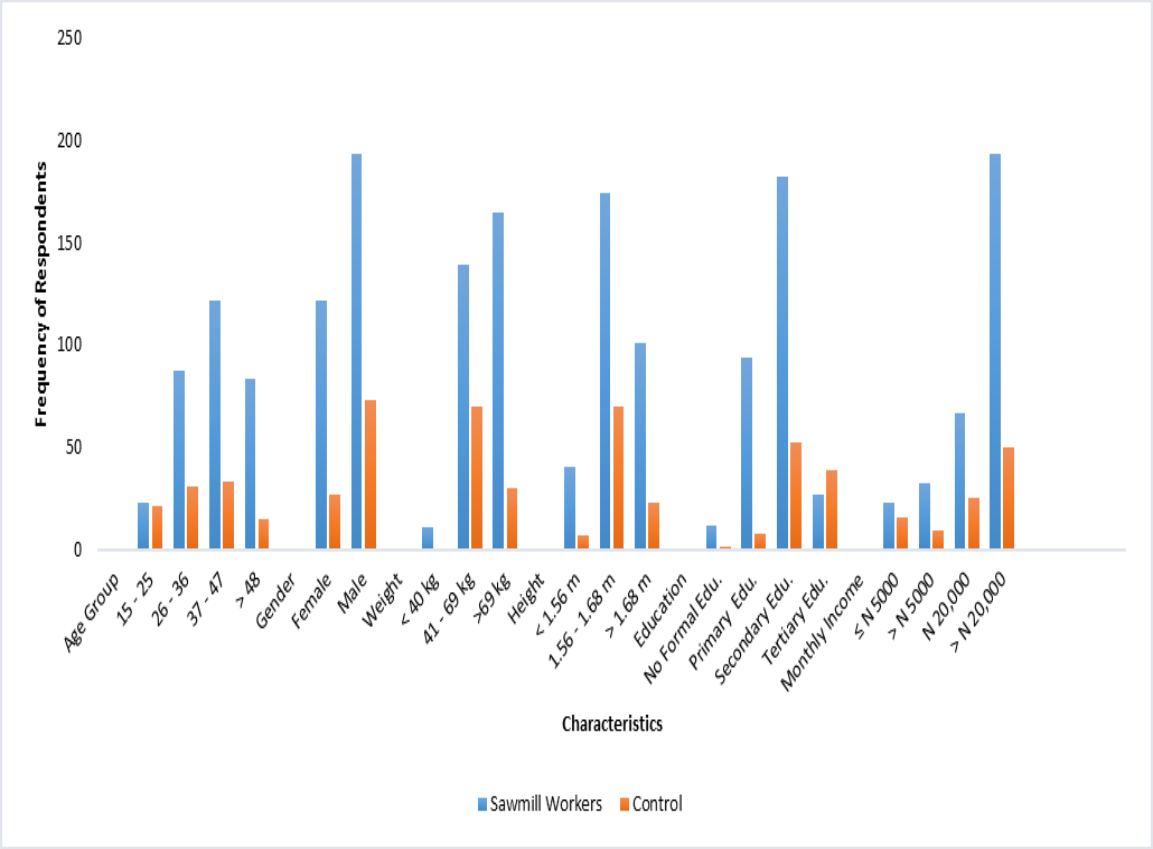

Figure 2. Socio-demographic characteristics of sawmill workers and the control group in Abeokuta

Concentration of ambient air particulate matter in each section of Lafenwa Sawmill Complex Abeokuta

The total suspended particles,$PM_{2.5}$ and PM_{10} observed in sawmill sections ranged from 104 – 482 μg/m^3, 42.1 – 195 μg/m^3 and 18.9 – 94.7 μg/m^3, respectively (Table 2). A higher concentration of total suspended particulate (TSP) was obtained at the Circular Machine Section (482±0.13 μg/m^3) compared to other sections like Plaining, Bawn, Tyrod and Plank Selling (B) Sections 245±0.02 μg/m^3, 376±0.01 μg/m^3, 385±0.01 μg/m^3 and 425±0.02 μg/m^3, respectively (Table 2).

Table 1. Work conditions and safety of sawmill workers in the workplace

Characteristics	Frequency	%
Work Sections		
Wood Drawer	1	0.3
Food seller	8	2.5
Loader/Packer	26	8.3
Machine operator	78	24.8
Manager/Servicing	5	1.6
Plank seller	170	54.0
Others	27	8.6
Total	**315**	**100**
Working Years		
< 4 years	50	15.9
5 – 9 years	58	18.4
10 – 14 years	50	15.9
>15 years	157	49.8
Total	**315**	**100**
Daily Work Hours		
< 8 hours	29	9.2
8 hours	22	7.0
> 8 hours	264	83.8
Total	**315**	**100**
Use of PPE		
Yes	8	2.5
No	306	97.1
Total	**315**	**100**
Wood Dust Management Style		
Abandonment	39	12.4
Burning	175	55.6
Disposal in water/elsewhere	87	27.6
Evacuation	14	4.4
Health Insurance		
Yes	18	5.7
No	297	94.3
Total	**315**	**100**

PPE – Personal protective equipment

Table 2 Concentrations of Particulate Matter at each section of Lafenwa Sawmill Complex in Abeokuta

Sawmill Section	TSP (μg/m³)	PM_{10}(μg/m³)	$PM_{2.5}$(μg/m³)
Plaining Section	245±0.02	56.7±0.03	30.7±0.48
Bawn Sawing Section	376±0.01	105±0.58	55.3±0.16
Plank Selling Section (A)	185±0.07	48.5±0.67	29.3±0.35
Circular Machine Section	482±0.13	195±0.49	94.7±1.50
Tyrod Section	385±0.01	138±0.46	81.2±0.50
Plank Selling Section (B)	425±0.02	163±1.08	88.4±0.47
Food Selling Section	215.6±0.03	57.9±0.09	26.7±0.63
Wood Waste Burning Section	104±0.07	42.1±0.36	18.9±0.70
Control (2 km away from the sawmill)	70.4±0.24	19.9±0.08	7.82±0.20
Mean value	302±0.04	101±0.47	53.1±0.60
(USEPA, 2022)	-	50.00	25.00
(USEPA, 2012)		150.00	35.00

***TSP – Total Suspended Particulate**

Lung function parameters of sawmill workers and the control group

The mean PEFR value of sawmill workers was 2.85 compared to the (3.55) control group (Table 3). The mean FEV_1% value of exposed workers was 66.2 compared to the (74.6) control group. The mean FEV_1 value for the subjects was 0.95 as compared to the control group of 1.11. The mean FVC value of exposed workers was 1.44 compared to the control group of 1.56 (Table 3).

Table 3. Lung function parameters of sawmill workers and the control group

	Mean ±S.D		*P*-value
	Sawmill workers	Control	
Lungs parameters			
PEFR	2.85±2.45	3.55±2.46	0.013*
FEV_1%	66.2±30.96	74.6±24.20	0.013*
FEV_1	0.95±0.66	1.11±0.69	0.033*
FVC	1.44±1.08	1.56±0.81	0.269

*P< 0.05

PERF - Peak Expiratory Flow Rate, FEV_1% - ratio of FEV_1 and FVC, FEV_1 - Forced Expiratory Volume in one second, and FVC – Forced Vital Capacity

Relationship between risk factors and lung function parameters of subjects

A significant negative correlation ($p<0.05$) was found between exposure to wood dust and PEFR ($r = -0.121$), FEV_1% ($r = -0.121$), and FEV_1 ($r = -0.105$), age and PEFR ($r = -0.136$), FEV_1% ($r = -0.252$), FEV_1 ($r = -0.155$), and FVC ($r = -0.097$). Significant positive correlation ($p<0.05$)was observed between gender and PEFR ($r = 0.290$), FEV_1% ($r = 0.126$), FEV_1 ($r = 0.296$), and FVC ($r = 0.274$). These risk factors; working years, daily work hour, use of PPE, and working section were not significantly correlated with the lung function parameters (Table 4).

Table 4. Relationship between risk factors and lung function parameters of subjects

	Correlation Coefficient			
Factors	**PEFR**	**FEV_1%**	**FEV_1**	**FVC**
Exposure (Sawmill/ Control)	-0.121*	-0.121*	-0.105*	-0.054
Working year	0.062	-0.024	0.016	-0.006
Daily work hour	-0.013	-0.029	-0.047	-0.013
Use of PPE	0.014	-0.018	0.038	0.055
Work section	0.047	0.015	0.003	-0.035
Night operations	-0.182*	-0.066	-0.109	-0.088
Age	-0.136*	-0.252*	-0.155*	-0.097*
Gender	0.290*	0.126*	0.296*	0.274*
Body Mass Index	-0.069	-0.063	-0.069	-0.076

*P<0.05

PERF - Peak Expiratory Flow Rate, FEV_1% - ratio of FEV_1 and FVC, FEV_1 - Forced Expiratory Volume in one second, FVC – Forced Vital Capacity

Comparison of common ailments among sawmill workers and the control group

Self-reported prevalent respiratory symptoms among the sawmill workers was as follows: sneeze (12.7%), running nose (10.8%), eye irritation (10.8%), cough (6.3%), chest pain(6.3%), skin irritation (5.4%), chest tightness (5.1%) and 5.1% phlegm compared to the control group with running nose (11.0%), sneeze (11.0%), cough (3.0%) and 2.0% phlegm (Table 5).

Table 5. Comparison of common ailments among sawmill workers and the control group

	Respondents		*P*-value
	Sawmill workers N (%)	Control N (%)	
Phlegm			
Frequently	16 (5.1)	2 (2.0)	0.040*
Occasionally	88 (27.9)	18 (18.0)	
Rarely	211 (67.0)	80 (80.0)	
Cough			
Frequently	20 (6.3)	3 (3.0)	0.328
Occasionally	107 (34.0)	31 (31.0)	
Rarely	188 (59.7)	66 (66.0)	
Chest tightness			
Frequently	16 (5.1)	0 (0.0)	< 0.001*
Occasionally	72 (22.9)	4 (4.0)	
Rarely	227 (72.1)	96 (96.0)	
Chest pain			
Frequently	20 (6.3)	0 (0.0)	<0.001*
Occasionally	81 (25.7)	7 (7.0)	
Rarely	214 (67.9)	93 (93.0)	
Breathlessness			
Frequently	7 (2.2)	0 (0.0)	0.013*
Occasionally	40 (12.7)	4 (4.0)	
Rarely	268 (85.1)	96 (96.0)	
Running nose			
Frequently	34 (10.8)	11 (11.0)	0.974
Occasionally	149 (47.3)	46 (46.0)	
Rarely	132 (41.9)	43 (43.0)	
Sneeze			
Frequently	40 (12.7)	11 (11.0)	0.551
Occasionally	176 (56.1)	52 (52.0)	
Rarely	98 (31.2)	37 (37.0)	
Eye irritation			
Frequently	34 (10.8)	1 (1.0)	< 0.001*
Occasionally	128 (40.6)	18 (18.0)	
Rarely	153 (48.6)	81 (81.0)	
Skin irritation			
Frequently	17 (5.4)	0 (0.0)	< 0.001*
Occasionally	66 (21.0)	6 (6.0)	
Rarely	232 (73.7)	94 (94.0)	

*$P<0.05$

DISCUSSION

The socio-demographic characteristics of subjects revealed that adults within ages of 37 and 47 years formed a higher proportion of respondents. Majority of these respondents did not go beyond secondary schools, corroborating the fact that there was low literacy level among them. This finding supported the result of Osuchukwu *et al.*(2013) who reported that 10% of the wood factory workers out of 400 recruited in their study had tertiary education. Also, the result of this study was similar to the work of Ogotimong'are *et al.* (2017), which stated that majority of their respondents attained secondary school education. The BMI of the subjects was 26.7, while that of controls was 24.5, showed that the sawmill worker's BMI was beyond the recommended guideline values, indicating that significant numbers of sawmill workers were overweight, compared to the C with BMI below the permissible limits, showing that the C were healthy. The high BMI value reported in respect of sawmill workers was a sign of high possibility of being susceptible to sickness or ailments at the workplaces. This finding was similar to the work of Campbell *et al.* (2021).

Appraising the work conditions and safety of sawmill workers in their workplace revealed that there were no ventilation system and no dust suppression facility existed at any of those sawmills studied. The plank sellers and the machine operators formed the larger proportion of sawmill workers that might have worked for more than 15 years making them to be the major likely suspects of the respiratory symptoms and lung function disorders. This study observed that those who had worked for more than ten years in sawmills could manifest high tendencies of showing more respiratory ailments than those who had worked for less than 4 years in the job similar to the reports of (Douwes *et al.,* 2000; Olujimi *et al.,* 2016; Kherde and Dhokane, 2017). The results of this study does not agree with Tobin *et al.* (2016) which reported that machine operators were higher in numbers than sawmill workers among job categories investigated. The differences could be attributed to the categories of respondents recruited for both studies and variation in their responses.

Also, majority of the subjects in this study did not use PPE as a means of reducing adverse effect of dust inhalation among sawmill workers. Non-wearing of PPE might contribute largely to high prevalence of respiratory and pulmonary-related symptoms among the sawmill workers. This finding was similar to that reported by Elechi and Warmate (2019),which stated that there was a significant association between use of PPE and exposure to occupational health hazards among sawmills workers. Another issue that was connected to work conditions and safety of the sawmill workers in the workplace was the waste management strategy within the studied sawmills. More than half of the sawmill workers discarded their wastes through open-dump burning system. This waste management strategy pollutes the air quality that the sawmill workers often inhaled in the workplace. This discovery was similar to that of Oguntoke *et al.* (2013) which observed that wood waste burning practice in sawmills deteriorated air quality being inhaled by sawmill workers in their workplace and impacted negatively on the health of the sawmill workers.

The average concentration of inhalable dust in this present study exceeded the existing threshold limit value (TLV) set by USEPA (2012), but lower than TLV set by NIOSH

(1998) and HSE(2022). Similarly, the average concentration of dust reported by Tobin *et al.*(2016) and Neghab*et al.*(2018) were also higher than the TLV, although the dust concentration in the present study was slightly higher than those stated by Cormier *et al.* (2000) and Rathipe and Raphela (2022). This variation might be linked to air sampling equipment employed, geographical locations, timing of research, cleaning procedures and dust suppression facility in workplaces. It is important to state further that the unexpected higher concentration of particulate matter (TSP,$PM_{2.5}$and PM_{10}) was observed at the Plank Selling Section B compared to the Plank Selling A. The disparity could be linked to the location of the sawmill section. The former was situated nearby road at the main entrance of the sawmill where additional dust was emitted from vehicular emission. This finding was similar to the work of Oguntoke and Yusuf (2008) which observed that there was high vehicular volume around the same location investigated in this study.

The prevalence of respiratory symptoms among the sawmill workers in this study pointed to the fact that occupational exposure to wood dust might predispose them to a higher risk of developing pulmonary function disorders. This finding is in line with results from other studies (Osman and Pala, 2009; Osuchukwu *et al.,* 2013; Tobin *et al.,* 2016; Kargar-Shouroki *et al.,* 2020). The sawmill workers in this study reported higher prevalent respiratory symptoms of sneeze, running nose and cough production. It was observed that involvement of upper respiratory tract was more pronounced among the sawmill workers studied based on the prevalent respiratory symptoms documented in this study compared to lower respiratory tract involvement associated with respiratory symptoms like wheeze, chest pain, chest tightness and breathlessness. This finding was similar to that reported by Douwes *et al.*(2000), Demers *et al.* (2000), and Tobin *et al.* (2016). The observed respiratory symptoms in this study might be as a result of exposure of sawmill workers to wood dust and biohazards that irritated their cough receptors situated at the upper respiratory tract, resulting to cough and phlegm production (Mandryk *et al.,* 2000). Certain variations occurred in this study in relation to the most prevalent respiratory symptoms (sneeze and running nose), which had the highest percentage of occurrence compared to Tobin *et al.* (2016) who reported the prevalent respiratory symptoms in their studied groups cough 46.7%, phlegm production 50.2%, breathlessness 7.5%, wheeze 5.3%, chest pain 5.7% and chest tightness 10.1%. Running nose and oral cavity irritation were the most prevalent respiratory symptoms observed by Mahmoood *et al.* (2015). The disparity could be ascribed to sawmill workers exposure to wood irritants, or chemicals often employed in seasoning and preserving of newly processed wood to ward off pest, insect, fungus and worms attacks. Persistent exposure of sawmill workers to these aforementioned irritants could cause harm on their health (Elechi and Warmate, 2019).

The significant reduction in PEFR, FEV_1%, FEV_1, and FVC values among the sawmill workers compared to that of the control group was in line with the results of Tobin *et al.* (2016), Osman and Pala (2009), Ennin *et al.*(2015), Kherde and Dhokane (2017), and Neghab *et al.* (2018). The decline in pulmonary function indices in the sawmill workers could be attributed to the inhaled high particulate matter concentration in the sampled sawmills. This observation was evident in

sawmill workers who could not perform spirometric test successfully as a result of lung function defects they were experiencing. The quantum number of physical activities involved in wood processing coupled with the non-usage of respiratory protective devices might predispose sawmill workers to high exposure of respirable wood dust (Ennin *et al.,* 2015; Tobin *et al.,* 2016). Analysis of variance of lung function between the sawmill workers and the control group showed significant differences between the mean values of PEFR, FEV_1% and FEV_1 for both groups.

The correlation between the risk factors; exposure to wood and age and lung function parameters of the sawmill workers showed significant negative correlation with some spirometric values like PEFR, FEV_1% and FEV_1. The implication of this is that the higher the quantities of wood dust exposure of subjects in sawmills, the lower their pulmonary function capability. Also, as the age of the sawmill workers increased their lung function decreased. There is a significant positive correlation between gender and all the spirometric values, which implied that the lung function parameters values would increase in the male respondents recruited for this study than their female counterparts compared to other researchers: Ennin *et al.*(2015), Tobin *et al.* (2016),and Neghab*et al.*(2018) which recruited mainly males as respondents in their studies. It was reported that males were more susceptible to respiratory symptoms and lung function disorders due to the nature of work they did in sawmills similar to what this study obtained (Osman and Pala, 2009; Mijinyawa and Bello, 2010).

In conclusion, the study assessed ambient wood dust concentrations at sawmills, occurrence of respiratory disease symptoms and pulmonary function decline among occupationally exposed sawmill workers in Abeokuta Metropolis, Ogun State. These findings established that the concentrations of particulate matter measured at Lafenwa Sawmill Complex in Abeokuta were higher than the control site (Ita-Iyalode, Abeokuta) and the WHO guideline limits. The majority of sawmill workers did not use personal respiratory protective devices while working in sawmills. Consequently, this study showed that the frequently experienced respiratory symptoms in the sawmill workers followed this pattern: sneeze > running nose > chest pain > cough > chest tightness > phlegm > breathlessness. More than half of the subjects worked beyond 8 hours every day. As the duration of exposure to wood dust increased, the pulmonary disorders increased. Also, as the age of the sawmill workers increased, their pulmonary functions decreased. The sawmill workers were exposed to environmental pollution, dust hazard, had reduced pulmonary functions, higher prevalence of respiratory and pulmonary-related symptoms, possessed BMI value higher than the recommended guideline limits as compared to the control group. Use of personal protective equipment should be encouraged among sawmill workers to minimize the negative impact of dust on their health. Planting of trees around the sawmills should be embraced by sawmill workers so as to increase air dispersion and to aid dust trapping by leaves, thus, improving local air quality that sawmill workers breathe.

CONFLICT OF INTEREST

Authors report no conflict of interest

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