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Research Article

Influence of Varying Degree of Wood Dust Exposure on Pulmonary Function and Respiratory Symptoms among Wood Workers in Kano, North Western Nigeria

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Summary: One of the major occupation-related health challenges encountered by wood workers is respiratory disorder, which usually results from breathing in noxious or toxic chemicals such as wood dust. The aim of this study is to evaluate the respiratory functions and symptoms among wood workers exposed to varying degrees of wood dust in Kano, Nigeria. This descriptive cross-sectional study was carried out among 370 randomly selected wood workers in Kano wood market. Lung function test was performed, while semi-structured interviewer administered questionnaire was used to rate respiratory symptoms. The study demonstrated that there was low percentage predicted force expiratory volume at one minute (PPFEV1) and percentage predicted ratio of FEV1 and FVC, whereas, the percentage predicted forced vital capacity (PPFVC) of the respondents across all age groups remained unchanged. Similarly, a negative correlation was observed between degree of exposure to the hazards and lung function of the workers (r = -0.655, P-Value = 0.0001). A statistically significant association existed between exposure to wood dust and respiratory symptoms, thereby contributing to the observed manifestation of respiratory symptoms such as chronic cough, corrhiza, breathlessness and wheezing among 61% of wood dust exposed workers.

Keywords*: Wood workers, Wood dust, Occupational hazard, Lung function, Respiratory symptoms*

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INTRODUCTION

Occupational exposure to widely used chemical and biological substances in work environment has long been acknowledged as cause of numerous diseases (Kim *et al* ., 2011; Montano, 2014). Wood dust is one substance that is strongly associated with respiratory diseases and lung function impairment (Ratnasingam *et al* ., 2014; Masoud *et al* ., 2018). Wood Processing results in the formation of wood chips and dust which could be partly suspended in the air and inhaled by the workers (Anders *et al* , 2002). High moisture content in fresh wood makes it less airborne relative to dry wood, which produces more dust during processing such as sawing and sanding. Soft wood particles are more fibrous and usually larger and as a result are also less capable of becoming airborne (Workers Health Center Fact Sheet, 2004). Concentration of wood dust in the industry varies in depending on the type of woodwork. The highest exposures have generally been reported in wood furniture and cabinet manufacture, especially during machine sanding and similar occupations (with wood dust level frequently above 5mg/m3) (Wood Dust Study Group 1, 1995). And 5 mg/m3 inhalable exposure limit was adopted in 1988. However, reduced lung function impairment was observed after long-term exposure to dust from soft wood at levels of 1.3 mg/m3 (Hessel, 1995) and 3.8 mg/m3 (Shamssain, 1992). Wood dust generated in the processing of wood for a wide range of uses is a complex substance. It is composed of cellulose fibres, resins and contaminants such as fungal spores and other microbes, wood preservatives, coatings, sealants and glues (e.g formaldehyde, pentachlorophenol, glycols, copper, naphthanate, e.t.c). This mixture makes it difficult to determine a specific irritant or allergen (SAFE work, 2005). However, the irritation symptoms in wood dust exposure are generally caused by the physical nature of wood dust particle. Thus, particle size is an important factor. The size of the dust particle produced the amount of dust and resultant exposure to staff working in these areas depends on a number of factors including the equipment being used, the ventilation and extraction system in place, the state and type of timber, general ventilation in the area and use of personal protective equipment.

The smaller the dust particle the further it will travel into the lungs causing symptoms of inflammation or allergy after repeated exposure (SAFE Work, 2005). Despite the numerous information regarding the effect of wood dust on lung function and respiratory symptoms, there is paucity of studies on influence of varying degree of wood dust exposure on lung function and respiratory symptoms of wood workers. Therefore, the present investigation is to study the degree of exposure to dust and other hazards in wood industry and resultant lung function impairment and respiratory symptoms.

MATERIALS AND METHODS

Study design and location: The study is a descriptive cross–sectional, conducted in Na'ibawa wood market Kano, Nigeria. The source of raw materials for the market is largely from the southern part of Nigeria and some parts of north central geopolitical zone of the country. Some of the common woods used in the market include black Akpara, Congo Akpara, white Akpara, Mansonia, Mahogany and Iroko.

Participants: All wood workers in Na'ibawa market were part of the study. However, workers with history suggestive of chest infection, known cases of asthma and chronic obstructive lung disease (COPD) before starting the job, known hypertensive patients were excluded from the study.

Data collection: Data was collected using a semi-structured interviewer administered questionnaire. A Vitalograph Electronic Spirometer Compact II was used for lung function study, Bathroom scale (Model Hamason, China) for measuring weight in Kg and Stadiometer for measuring height in cm.

Exposure to wood dust was calculated using exposure-rating system adapted from a past study by Ministry of manpower Singapore in 2006. An exposure rating scale of 1 to 5 points, where 1 represent very low exposure and 5 represents very high exposure, while 3 equals medium exposure was used in the analysis (Ministry of manpower Singapore, 2006) (Table 1).

Lung function was assessed by comparing measured values with predicted reference values of lung function parameters (FVC, FEV_1, and FEV_1/FVC) for that age, weight and height automatically generated by the Vitalograph Compact II electronic Spirometer, based on Kundson's formula for calculating lung function parameters in blacks. A value of the measured parameters > 75% of its predicted value was adjudged as normal. A value of > 65% but less than 75% was interpreted as mild lung function impairment (restrictive or obstructive) while that > 50% but less than 65% was interpreted as moderate lung impairment, and any value less than 50% of its predicted was adjudged as severe impairment of lung function.

The relationship between degree of exposure to hazards of wood work and lung function was determined using correlation plot, and the strength of the association was obtained using correlation coefficient (r). Chi-square test (χ^2) was used to determine significant association between degree of exposure to hazards of wood work with lung function impairment and respiratory symptoms. A confidence interval of 95% used and a p-value of < 0.05 were considered significant.

Data analysis: Data collected were collated and analyzed using the statistical package for social science (SPSS) version 22 (SPSS Statistics for Windows, version 22. Armonk, NY: IBM Corp.). Quantitative variables were summarized using mean and standard deviation, while categorical variable were summarized using frequencies and percentages as appropriate.

Ethical consideration: Ethical clearance (protocol no: ABUTH/PGO/COMM/9 dated 13th September, 2006) and permission for the study were sought and obtained from the Medical Ethical Committee of Ahmadu Bello University, Zaria, and Kumbotso Local Government Kano, Kano State, respectively. Informed consent was obtained from each participant before enrolling for the study.

Table 1:
Exposure Rating modified from 'Method to Assess Occupational Exposure to Harmful chemicals.

Exposure Factor	Exposure index				
	1	**2**	**3**	**4**	**5**
Particle Size	Coarse, bulk wet material	Coarse and dry material	Dry and small partial size	Dry and fine material	Dry fine powdered material
Vapour	-	-	-	-	Vaporizing chemical
Hazard Control Measure	Adequate control with regular maintenance	Adequate control with irregular maintenance	Adequate control without maintenance (moderate/dusty)	Inadequate control, dusty	No control at all, very dusty
Amount Used Per Week	Almost negligible <1kg or	Little amount used 1 - <10kg	Medium amount, workers are trained on handling dust 10 - <100kg	Large amount used, workers trained 100 – 1000kg	Large amount used, workers not trained >1000kg
Duration Of Work Per Week	< 8 hours	8 – 16 hours	16 – 24 hours	24 – 32 hours	>32 hours

Calculation

$ER = [EI_1 \times EI_2 \times \ldots\ldots \times EI_n]^{1/n}$

Where;

EI = Exposure Index

n = number of factors used. *ER score = 1 – 5*

1 = Very low *2 = low* *3 = medium* *4 = High* *5 = very high*

RESULTS

Three hundred and seventy (370) wood workers were recruited for the study. The respondents' engaged in different types of wood work namely trading, sawing, sanding, joinery, staking and spraying. Majority of the wood workers, 99 (26.7%) were involved in sawing of wood, whereas those involved in spraying of the wood constitute only 42 (11.3%) of the 370 wood workers. The means and range of respondents' ages, weights and heights by the type of work they do are as shown in table 2.

Table 3 shows the mean ventilatory indices of the respondents by their age group. The result observed low percentage predicted force expiratory volume at one minute ($PPFEV_1$) across the ages 25-34 and 45-59 years. However, the percentage predicted forced vital capacity (PPFVC) of the respondents across all age group was normal. The percentage predicted ratio of FEV1/FVC across the age group 25 to 34 years was lower than normal. Table 4 observed that cough to be the most common symptom among the respondents 134 (36.0%) followed by sneezing 93 (25.0%). On the other hand, wheeze was the least common symptom among the wood workers 23 (6.0%). Overall, 228 (61.6%) of the wood workers had respiratory symptoms.

The degree of exposure of the wood workers to hazards in their places of work measured by exposure rating is depicted in figure 1. More than a quarter 116 (31.0%) of the exposed workers had high exposure rating (3-5). The degree of exposure to hazards in woodwork place was significantly associated with lung function ($\chi^2 = 261.1$, df = 1, p = 0.01) as shown in Table 5. Up to 113 (97.4%) of the woodworkers that had impaired lung function had high degree of exposure, whereas 229 (90.1%) of those that had normal lung function had low degree of exposure. Furthermore, a negative correlation was observed between degree of exposure to the hazards and lung function of the workers (r = -0.655, P-Value = 0.0001). As degree of exposure increases, lung function decreases as depicted in Figure 2. This study also observed that degree of exposure to hazards of the woodwork was significantly associated with prevalence of respiratory symptoms ($\chi^2 = 16.2$, df = 1, p = 0.001) as shown in Table 5

Table 2:
Mean Values of Age, Weight and Height of Respondents by Their Type of Work

Type of work (n)	Mean age in years (Range)	Mean weight in kg (Range)	Mean height in cm (Range)
Sawing (99)	33.9 (16-54)	66.1 (45-88)	168.8 (150-184)
Sanding (52)	36.5 (19-56)	64.4 (49-88)	166.9 (156-178)
Stacking (66)	32.5 19-56()	64.9 (48-92)	166.4 (150-178)
Joinery (50)	31.8 (17-56)	63.5 (41-90)	166.5 (155-178)
Spraying (42)	32.2 (18-55)	64.4 (48-84)	167.4 (154-181)
Trading (61)	29.1 (17-56)	63.6 (38-87)	168.2 (155-182)

Table 3:
Mean Ventilatory Indices of the Wood Workers by Their Age Group

Age group	FEV_1M(l) Mean ± S.D	FEV_1P(l) Mean ±S.D	$PPFEV_1$ (%) Mean ± S.D	FVCM(l) Mean ±S.D	FVCP (l) Mean ±S.D	PPFVC (%) Mean ± S.D	$PPFEV_1$ /PPFVC (%)Mean ±S.D
15-19	2.43± 0.50	3.05±0.10	79.59±14.89	2.97±0.44	3.50±0.40	85.33±9.92	77.86 ± 9.31
20-24	2.24± 0.51	3.14±0.28	75.80±15.26	3.11±0.42	3.52±0.34	88.72±10.46	75.81 ± 10.86
25-29	2.29± 0.30	3.10±0.26	*73.87±16.29	3.13±0.34	3.53±0.32	88.82±8.51	*74.16±10.46
30-34	2.40± 0.27	3.27±0.32	*73.60±15.28	3.16±0.42	3.79±0.41	83.53±7.72	*73.82 ± 8.14
35-39	2.54± 0.20	3.25±0.29	78.24±12.54	3.09±0.36	3.75±0.31	82.40±8.37	77.51 ± 10.29
40-44	2.53± 0.14	3.10±0.15	81.45±10.54	2.83±0.35	3.55±0.2	79.77±9.65	79.83 ± 7.76
45-49	2.22± 0.21	3.09±0.17	*72.18±15.58	2.82±0.32	3.45±0.13	81.87±9.72	75.86 ± 7.06
50-54	2.24± 0.20	3.11±0.15	*72.10±14.01	2.72±0.29	3.45±0.19	79.15±10.09	78.04 ± 5.87
55-59	2.07± 0.15	2.94±0.19	*70.94±14.34	2.70±0.19	3.24±0.17	83.45±5.40	78.28 ± 12.83

*Key:*Lung function impairment, FVCM = Measured FVC; FVCP = Predicted FVC; PPFVC = % predicted FVC; FEV_1M =Measured FEV_1; FEV_1P = Predicted FEV_1; $PPFEV_1$ = % predicted FEV_1; $PPFEV_1$ /PPFVC% = % predicted FEV_1 to % predicted FVC ratio.*

Table 4:
Common Respiratory Symptoms among the Respondents

Sneezing	93 (25.0)
Regular blocked nose	44 (11.8)
Runny nose	48 (12.9)
Wheeze	23 (6.0)
Breathlessness	58 (15.6)
Tightness of chest	76 (20.5)
Cough	134 (36.0)

DISCUSSION

Pulmonary function tests detect impairment in lung function and assess the effect of treatment or progress of a disease. Forced Expiratory Volume in one second (FEV_1), Forced Vital Capacity (FVC) and Peak Expiratory Flow Rate (PEFR) are simple routine procedures which can be undertaken by health workers without special training (Cromopton *et al* , 1999). FEV_1/FVC ratio is the forced expiratory volume in 1 second expressed as a percentage of forced vital capacity, and gives a clinical index of airflow.

Table 5:
Factors Associated with Degree of Exposure to Hazards of Wood Work

Factor	Degree of exposure		
	High Freq (%) (n=116)	**Low Freq (%) (n=254)**	**Chi-square (p- value)**
Lung function			
Normal (% predicted ratio ≥75%)	3 (2.6)	229 (90.2)	261.1 (0.0001)*
Impaired (% predicted ratio < 75%)	113 (97.4)	25 (9.8)	
Respiratory symptom			
Symptom	54 (46.6)	174 (68.5)	16.1 (0.0001)*
No symptom	62 (53.4)	80 (31.5)	

* denotes p<0.05, statistically significant association

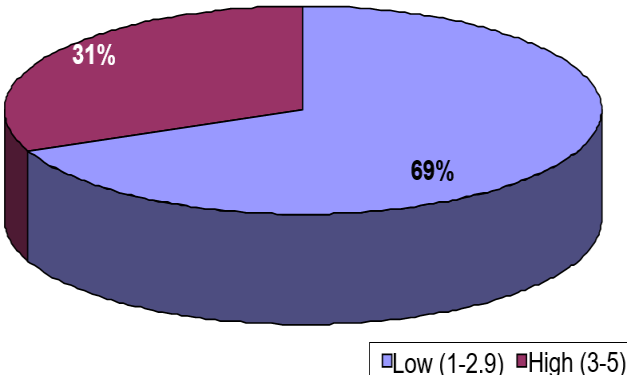

Figure 1:
Exposure Rating (ER) of Wood Workers

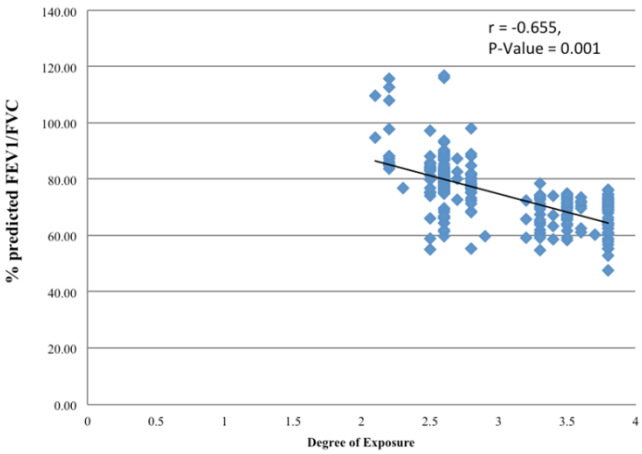

Figure 2.
Relationship between Degree of Exposure to Hazards of Wood Work and Lung Function.

The American thoracic Association (ATS) defines obstructive disease as that in which maximal airflow (FEV) is disproportionately reduced with respect to the volumes of air a subject can exhale from full expiration (FVC).

In this study, the mean percentages of the predicted FVC for all age groups were within normal values. The percentage predicted means FEV_1 was however low for the subjects between 25 -34 years and those between 45 – 59 years old. The mean FEV_1/FVC for the wood workers across most of the age group were similarly normal except for the age groups 25 – 29years and 30 – 34years that had 74.16% and 73.82% of their predicted values respectively. The decrease could be as a result of those within that age involved more in jobs that have highest exposures to wood dust and chemicals (sanding and spraying). This pattern of lung function observed among the subjects in this study clearly depicts the obstructive pattern of lung function impairment. Lung function impairment was similarly reported by other researchers in Nigeria and elsewhere, amongst workers who were exposed to wood dust and other lung irritants in their work places (Bosan and Okpapi, 2004; Demissie, 2019). The reduction in FEV_1 in the older age groups may be explained by the fact that lung function reduces by age. The common respiratory symptoms associated with woodwork in this study include sneezing, regular blocked nose, runny nose, wheeze, breathlessness, tightness of chest and cough. Cough and sneezing were the two (2) most common occurring symptoms. However, wheeze occurred least among the wood workers. Similar finding was reported in past studies (Bosan and Okpapi, 2004; Chirdan and Akosu, 2004; Håkan *et al* , 2017). In addition, significant relationship between degree of exposure and lung function, and with prevalence of respiratory symptoms was also demonstrated in this study. Chirdan and Akosu, 2004; Bosan and Okpapi, 2004 also reported similar findings. This could be associated with similarities in the study group.

This study also observed that lung function impairment also increases with increase in degree of exposure. From the findings it has been shown that people who were exposed more have impairment of lung function more than those with lower exposure. Exposure to chemical used as coating and preservatives in the wood industry also cause lung function impairment. The wood dust and chemical formed produce damaging effect on the respiratory tract through allergic reaction as a direct irritant effect and or chronic inflammatory responses. As a result, respiratory symptoms such as chronic cough, corrhiza, breathlessness and wheezing manifest as found in the current study.

In conclusion, the study found obstructive lung function impairment among those who engaged more in sanding and spraying. The study also observed a negative correlation between degree of exposure to the hazards in the work place and lung function of the workers. As the exposure increases, lung function decreases. More attention should be paid to the provision of vents and use of mask in the wood work places.

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