Chronic Obstructive Pulmonary Disease as Measured By FEV1, FVC AND, FEV1/FVC Ratio Among Saw Mill Workers in Jos, Northern Nigeria

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ABSTRACT

BACKGROUND

The lung is organ most affected by occupation-related toxin inhalation after the skin. Exposure to wood dust is associated with serious health hazards, including chronic obstructive pulmonary disease (COPD). This study was conducted to determine the prevalence and severity of COPD among saw mill workers in an urban metropolis in North central Nigeria.

METHODOLOGY

In this case-control study, we compared the prevalence of COPD amongst 200 healthy adults and 200 workers employed at four saw mills in Jos, North central Nigeria. In both subjects and control groups, we assessed ventilatory function using a vitalograph spirometer to measure FEV1, FVC, and FEV1/FVC ratio.

RESULTS

Amongst the control group, various respiratory symptoms were prevalent in 0-2% of subjects, while impaired FEV1 and FVC values suggestive of an obstructive ventilatory defect was detected in 1%. Amongst study subjects, respiratory symptoms were prevalent in 22-80%, while impaired FEV1 and FVC values was detected in 40%, of whom 35% had an obstructive defect and 5% had a restrictive defect.

CONCLUSIONS

Respiratory symptoms and COPD are prevalent among saw mill workers in Northern Nigeria, where exposure to saw dust can be reduced by improved working conditions and better public awareness.

KEYWORDS

COPD; Spirometry; Sawmill workers; Nigeria.

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INTRODUCTION

The lungs, next to the skin, is the second most common organ affected by occupation-related toxins[1]. Inhalation of foreign material at the work place can cause a number of pulmonary syndromes which have been recognized as major contributing factors to all non-vascular pulmonary disease worldwide[1]. Exposure to wood dust and substances connected with wood-processing has been associated with a variety of respiratory diseases involving both the upper and lower respiratory tracts[2].

Many fumes, gases, vapors, dust and other inhaled substances have potentially toxic effect that are manifested by pulmonary as well as extra pulmonary injury[3]. The relationship between occupation and lung disease was recognized as early as the 18th century[4].

Saw milling work has been carried on for centuries and the earliest known reference to a working sawmill comes from a Roman poet Ausonius who wrote an epic poem about the River Moselle in Germany in the 4th century AD. Prior to the invention of sawmill, sawing of wood was done manually by men using a whipsaw[5]. In the twentieth century the introduction of electricity and high technology further made progress with this process, and now most sawmills are massive and extremely expansive in which almost every aspect of the work is computerized. Today a mill can make many hundreds of thousands of boards per day[5]. In Nigeria, wood work has also been around for centuries. It was the main source of raw materials for construction of shelter and farming since pre-colonial times. However, it is yet to attain full mechanization.

Exposure to wood dust, organic and inorganic, has long been associated with a variety of adverse health effects, including dermatitis, allergic respiratory effects, mucosal and non allergic respiratory effects and cancer[6,7]. Both the skin and the respiratory system can become sensitized to wood dust. A worker so sensitized can suffer severe allergic reactions after repeated exposure or prolonged exposure to lower concentrations of dust[8].

The respiratory effects of wood dust exposure include Chronic Obstructive Pulmonary Disease (COPD), diagnosed based on standardized spirometry procedure[11]. An asthma-like condition, hypersensitivity pneumonitis and chronic bronchitis[9,10]. In Nigeria, there is increase in prevalence of respiratory symptoms, and associated decline in ventilatory function among saw mill workers compared to the general population and the prevalence of such symptoms was found to be dependent on the duration of exposure to wood dust[9].

The recognition of a relationship between respiratory disease and working environment is an integral part of labor laws in both developing and developed nations. The effect of exposure to wood dust on saw mill workers in Jos plateau was looked at in this study. This study will help to achieve the establishment of substantial link between sawdust, environment and respiratory disease; provide evidence for timely implementation of preventive strategies and treatment of the exposed subjects so in order to improve the prognosis of such risk; create awareness among saw mill workers in terms of preventive strategies and compensation purposes and diagnose respiratory diseases that can be precipitated or exacerbated by such work places, leading to a change in work place of such patient so as to improve patient's quality of life and prognosis.

METHODOLOGY

This was a cross sectional case-control study aimed at determining respiratory symptoms and ventilatory function among sawmill workers in Jos metropolis of Plateau State in Nigeria.

The city of Jos has an area of about 1,695 square kilometers, and it is about 1250 meters above sea level, lying between longitude 80 53/ and latitude 90 56/. It has a population of about half a million people[12,13]. Placed on the highland of the Plateau, the city enjoys climate that has made it a holiday city[13].

Four major timber sheds located within the city was used for this study. Each of the timber shed is about the same size with an estimated population of about 150 Saw mill workers, Data collection was done during day time from 8.00am to 4.00pm.

Study subject

Study subjects were chosen from the population by simple random sampling method. About 200 subjects were recruited for the study and 25% of the subjects were selected from each timber shade irrespective of their work schedule. Group-mean exposure categories have previously been shown to result in less biased exposure estimates in the wood processing industry[8].

Control group comprised of staff of the Jos University Teaching Hospital who had no history of chronic chest ailments, chest surgery or chest wall deformities and who had no history of occupational exposure to dust and had not lived near mines, quarries, cotton ginneries, or cement and flour factories. Controls were selected through random sampling but were matched to study subject with respect to age, height and weight.

All study subjects had an informed consent signed and ethical approval was obtained from Jos University Teaching Hospital ethical committee. Subjects were included in the study if they were aged eighteen years or more, and had over six months exposure to saw dust while working at a timber shade. A Modified British Medical Research Council (MRC) questionnaire was used in this study[14].

A history of occupational exposure to saw dust and previous respiratory symptoms prior to employment was obtained from the participants and thorough physical examination done on each subject including anthropometric measurement. The subject's weight (in kg) and standing height (in meter) were measured using a stadiometer.

Spirometry

Spirometry was performed with subjects standing relaxed with the head in a horizontal position. Subjects were asked to perform forced expiratory maneuvers from total lung capacity to residual volume, to obtain measurement of FVC and FEV1[11]. The best FEV1 and FVC values were taken from three technically satisfactory forced expiratory maneuvers, where the best two recordings were within 5% of each other. For the FEV1, FVC and PEFR, the highest value obtained after a few practice attempts was recorded for analysis.

Results were expressed as percentages of predicted normal values for Nigerian men and women[15,16]. FEV1 and FVC values were also expressed as percentages of predicted values for Nigerian adults using a regression equation[16].

A lung function assessment was carried out by means of a computerized Spirometer (Vitilograph-Alpha Spirometer).

Dust concentration at the timber shed was measured by dust sampler santorious instrument hanged in position where the saw mill workers normally stand during work at about 5m height[11]. Sampling time ranged from six to eight hours covering a work shift, after sampling the filters are removed and immediately re-weighed and the difference between the weight of the filter before and after was determined.

DATA ANALYSIS

Statistical analysis was done with SPSS for windows version 16.0 statistical software. Continuous variables with normal distributions were expressed as means (± standard deviation), including age, height, weight and lung function parameters of FEV1, FVC% and PEFR. Where continuous data were skewed, median values were stated as well.

Chi-square test was used to determine significance of association between variables where the expected frequencies were less than 5. Comparisons of proportions were accomplished using the fisher's exact test. Multiple linear logistic regression was used to describe the least effect of cumulative exposure on lung function (or symptoms), thereby correcting for age and duration of employment. To standardize for any age and height difference between individuals in both study and control groups, observed lung function values (FEV1, and FVC) were in addition expressed as percentage of predicted normal. This was done using age and height regression equations developed for normal Nigerian men[15,16,17].

Evaluation of pattern of lung function abnormality was based on the ventilatory ratio and American Thoracic Society statement on lung function testing. [11]Any observed value greater than 80% of the predicted value was considered normal and any FEV1/FVC value less than 70% was considered abnormal.

Subjects whose ventilatory ratios (FEV1/FVC) were less than 70% were categorized as having obstructive pattern of lung disease, while those whose vital capacity (VC) was reduced, and those whose ventilatory ratio were normal or high (FEV1/FVC %> 70%) are categorized as having a restrictive ventilatory defect[11]. Statistical significance was set at P<0.05 for all values of the t-test distribution and X2 test. Student t test was used to compare group means where appropriate.

RESULTS

A total of two hundred saw mill workers and 200 control subjects were enrolled for this study. The mean (SD) age of the study and control subjects were 31.82 ± 15.21 and 32.05±16.603respectively, (p= 0.8852). The mean (SD) heights of study and control subjects were 165.78 ± 6.96 and 166.26 ±7.020 respectively, (p= 0.4927). The mean (SD) weight of the study subjects was 62.64 ± 8.62 and that of the control subjects was 67.64 ± 8.619, (p= 0.3995). The Age, height and weight were normally distributed. The demographic characteristics of the study and controls subjects are shown in table 1.

Table 1 – Demographic Characteristics of the study population (mean ± SD)

	Study Subjects (n=200)	Study Control (n=200)	*P* value
Mean Age (yrs)	31.82 ± 15.21	32.05±16.603	0.8852
Height(m)	1.6578 ± 0.0696	1.6626±0.07020	0.4927
Weight (Kg)	62.64 ± 8.62	67.64±8.619	0.3995
BMI	22.79 ± 1.09	24.47± 1.24	
Duration at work	7.22 ± 7.03	7.18 ± 7.07	0.8613

The mean (SD) duration of employment of the subjects was 7.22 ± 7.03 years, with a median of 5 years and a range of 0.5 to 33 years (table I).

The dust concentration at the mill was measured by subjective assessment of dustiness of environment on a scale of 0-3 and mean dust concentration by dust sampler, this consist of a seven hole filter holder housing pre weighed poltytetrafluoroethene (PTFE) filters (1.2μmpore size, 25mm diameter, santorious instrument ltd, GB-Belmont, survey).

Sampling time ranged from six to eight hours covering a work shift, after sampling the filters are immediately re weighed on a santorious R180D balance so that the total dust concentration is calculated, this was also confirmed by the subjective assessment of the dustiness of the environment. The high exposure area of milling and sanding has dust concentration ranging from 4.4-22.4mg/m^3.

Age Distribution of subjects and control

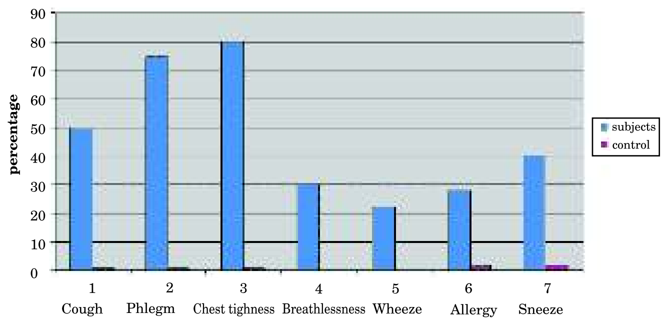
Thirty eight percent of saw mill workers and 42% of the controls were below twenty five years of age. The modal age group for Study and control subjects was 25 to 34 years. Subjects and controls showed similar distribution across the different age groups, see table 2.

Table 2: Frequency of symptoms among subjects and control

Age groups (years)	Study Subjects *n* (%)	Study Controls *N* (%)	*P* value
<25	76 (38.0)	86 (42.0)	0.475
25-34	69 (34.5)	54 (27.0)	0.129
35-44	13 (6.5)	15 (7.5)	0.845
45-54	16 (8.0)	19 (9.5)	0.723
55-64	14 (7.0)	14 (7.0)	1.000
>65	12 (6.0)	12 (6.0)	1.000

Chest tightness was noticed to be much frequent among the subjects than control(80% v 0.5%%), this was followed by sputum production (75% v 0.5%), cough (50% v 1%), sneeze (40% v 2%), breathlessness (30% v 0 %), allergy (28% v 1.5%) and wheeze (22% v 0%).

Figure 1:



PULMONARY FUNCTION TESTS

The mean FEV1 was 2.79 ± 0.79 L in the subjects and 2.84 ± 0.49 L in the controls (P=0.4473). The mean FVC was 3.45 ± 0.54 L in subjects and 3.89 ± 0.51L in controls (P=<0.0001). The mean ratio of FEV1/FVC in subjects was 68.76 ± 15.69 and the control was 82.1±3.5 (p=<0.0001) .The mean PEFR was 522.93 ± 110.81 L/min in saw mill workers and 552.0± 51.0 L/min in the control group (P=0.008), see table 3 below.

There was a fall in FEV1 with advancing age in the subjects compared to control, as shown in figure 2.

Table 3: The mean ventilatory indices for Exposed and Control subjects

Lung function	Subjects: Exposed	Subjects: Control	*P* value
FEV1	2.79 ± 0.79	2.84 ± 0.49	0.4473
FVC	3.45 ± 0.54	3.89 ± 0.51	0.0001*
FEV1/FVC	71.76 ± 15.69	82.1 ± 3.5	0.0001*
PEFR	522.93 ± 110.81	552.0 ± 51.0	0.0008*

Table 4: Mean values of lung function in subjects exposed compared with predicted values

Lung function	Subjects: Exposed	Subjects: Predicted	*P* value
FEV1	2.79± 0.79	3.30 ± 0.43	0.432
FVC	3.89 ± 0.54	3.62 ± 0.43	0.001*
FEV1/FVC	71.76 ± 15.69	92.25 ± 3.69	0.000*
PEFR	522.93±110.81	548.12 ± 35.92	0.128

*statistically significant

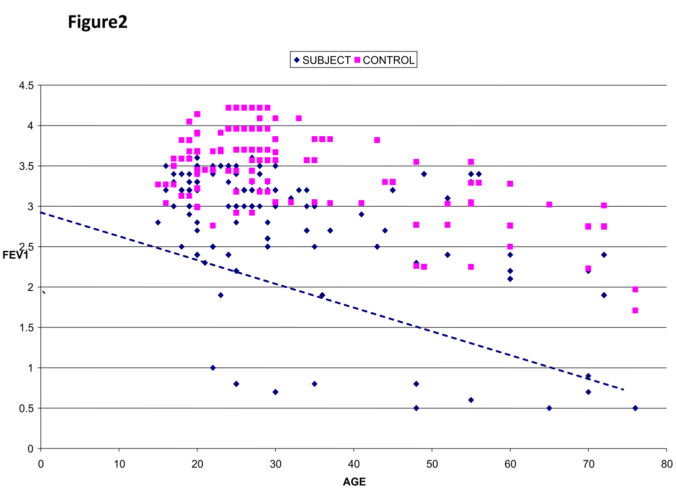


Figure 3: Pattern of Ventilatory defect in subjects and control

An obstructive pattern of lung function (FEV1% <70%) was found in 69 (35%) of study compared to 1% in control subjects. 5% of the subject presented with restrictive pattern compared to none of the control

Nine (5%) of the study subjects had restrictive pattern compared to none of the control based on the criteria of FVC values less than 80% of predicted values for age and sex matched Nigerians, FEV1 ≤ 70%, and FEV1 / FVC > 80% is suggestive of a restrictive pattern of lung function defect. No member of the control group had a restrictive pattern of lung function defect see table V below.

Table 5: Pattern of Ventilation impairment in study and controls subjects

Ventilation defect	Study Subjects	Control subjects
Obstructive	69 (35%)	1(<1%)
Restrictive	9(5%)	0

DISCUSSION

In this study subjects were chosen from the population by simple random sampling method. About 200 subjects were recruited for the study and 25% of the subjects were selected from each timber shade irrespective of their work schedule. Group-mean exposure categories have previously been shown to result in less biased exposure estimates in the wood processing industry[26,27,28].

Exposure to organic and inorganic dust has been associated with a negative impact on respiratory system. The effect of wood dust exposure by saw mill workers was considered in this study.

Among the various type of organic dust to which human are exposed to, wood dust is one of the most important[2]. A mean exposure of around 1mg/m^3 wood dust is considered to be a mucous membrane irritant and may cause, chronic obstructive pulmonary disease (COPD), allergy, asthma and nasal cancer mostly adenocarcinoma[8,9,10].

Although no clear distinction in health risk between different types of wood species can be made, hard wood seems to constitute greater health risk than soft wood for most health effects[7].

Respiratory effects induced by wood dust are assumed to follow roughly the same mechanism as other organic dusts such as grain dust and cotton dust, through the release of inflammatory mediators from inflammatory and epithelial cells[7].

Chronic obstructive pulmonary disease (COPD) is a group of chronic and slowly progressive respiratory disorders characterized by airflow limitation. Most of the airflow obstruction is fixed, but a variable degree of reversibility and bronchial hyperactivity may be seen.

Endotoxins (lipopolysaccharide protein complexes, which are integral part of gram-negative bacteria) and allergic fungi are the main biohazards found in wood processing workplaces.[18]Chest tightness, cough, shortness of breath, fever, and wheezing have been observed in workers exposed to airborne Endotoxins[18]. Endotoxins may be an important causative agent in the development of chronic bronchitis associated with organic dust exposure[19]. Exposure to wood dust can modulate the expression of macrophage derived cytokines and chemokines[20].

Early allergic reactions to coniferous wood and to microorganisms associated with wood dust are common among sawmill workers, posing a potential risk of work-related disease in this occupational group[21, 22, 23].

This study shows a high prevalence of COPD and other respiratory symptoms among wood workers. The prevalence of respiratory symptoms in the subject was 93%.An obstructive pattern of lung function (FEV1% <70%) was found in 69 (35%) of study compared to 1% in control subjects. 5% of the subject presented with restrictive pattern compared to none of the control[4]. These study therefore suggest that there is a causal relationship between wood dust exposure and occurrence of COPD and other respiratory symptoms among Saw mill workers.

This is consistent with previous findings in sawmill workers processing western red cedar[1].

Reduced FEV1 and FVCs have also been reported for furniture workers exposed to dry pine dust[1].

Increasing prevalence of symptoms with increasing period and degree of exposure strongly support a causal relationship, the most probable explanation may be chronic inflammation from continuous exposure to the wood dust[21,22].

Age is unlikely to be a factor since there is no significant difference in mean ages among the working groups[23].

This study also indicates a work shift exacerbation of respiratory symptoms, about 73 (92%) of the 101 study subjects with respiratory symptoms had symptoms during the working hours. This is also similar to the outcome observed in a study among saw mill workers by V Schullensen et al[8,24].

The proportion of men with an FEV1/FVC below 70 was higher in exposed workers than in control subjects and higher in the exposed workers with more years of employment. The exposed workers had more respiratory symptoms than the control subjects, the prevalence, especially of cough and nasal symptoms, increasing with the increase in the number of years of employment. This is also consistent with the findings by MH Shamssain in Umtata southern African[25].

In this study the study subjects had significantly lower mean peak expiratory flow rates (PEFR), forced expiratory volume in one second (FEV1), forced vital capacity (FVC) and ratio (FEV1/FVC), although lower among saw mill workers than controls, the FEV1/FVC ratio was lower among study subjects compared to the Predicted values for age and height for Nigerian population. This is similar to the findings from previous studies done in high altitude zones of Lapaz, Bolivia[26,27]. Which is due to an enhanced lung volume occurring as an adaptive mechanism for persons staying at high altitudes in order to compensate for the fall in oxygen tension with increasing height, Jos, at an altitude of 1,250 meters above sea level is one of the highest points in Nigeria

CONCLUSIONS

This study has shown that exposure to high levels of wood dust is associated with increase prevalence of COPD and other respiratory symptoms. Which follow either an obstructive or a restrictive pattern as evidence by a decline in FEV1, FEV1/FVC and PEFR. Degree of exposure and lack of protective mask constitute a greater risk than otherwise.

This study also confirms that residents of high altitude have an enhanced lung volumes compared to those dwelling in the low planes.

Marked exposure to dust from more than one species of wood was observed. This could lead to varied inflammatory response and end results among saw mill workers.

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