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Original Research Article

A Study of Lung Function Indices of Woodworkers at the Accra Timber Market in Ghana

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Background: **Industrial ambient air particulate matter inhaled in the workplace can be hazardous to health. This study was carried out in Ghana at the Accra Timber Market (a cluster of sawmills). The woodworkers are constantly exposed to high amount of visible ambient air particulate matter, but they work without any respiratory protective devices.** ***Aim:*** **The study examined the effect of wood dust on the lung function indices of sawmill workers and the correlation between years of sawmill work and lung function.** ***Study Design:*** **A cross-sectional epidemiological study.** ***Method:*** **A sample of woodworkers was selected by cluster and convenient sampling method from the Accra Timber Market. The control group consisted of staff and students from the College of Health Sciences, University of Ghana, Korle Bu who had no history of wood dust exposure. Subjects' lung function tests were performed using a spirometer and responses to a modified version of Medical and Research Council questionnaire were taken. The ambient air particulate matters were measured using a standard air sampler.** ***Result:*** **A total of 104 woodworkers and 104 control subjects were studied. The mean (SE) concentration of particulate matter monitored within the Accra Timber Market was 392.33 (124.02) µg/m3. The VC, FEV1, FEV1%, PEFR and FEF 25-75% were significantly reduced in the wood workers relative to the control group. The reduction of the lung function parameters in the wood workers was associated with increased odds ratios compared to control, as well as increased relative ratios within woodworkers' group with regard to duration of exposure. There were more wood workers with one or more lung function parameters below normal values than the controls. High proportions of woodworkers showed presence of obstructive (37%) and restrictive (32%) ventilatory defect, against (22%) and (15%) respectively in the controls. The wood porters and machine operators showed high proportions of obstructive ventilatory defect whiles the carpenters showed a high proportion of restrictive ventilatory defects.** ***Conclusion:*** **Significantly high percentage of woodworkers had impaired respiratory function and this may be due to the high ambient air particulate matter and also to long unprotected exposure to wood dust.**

Keywords: Woodworkers, Ambient air particulate matter, Respiratory symptoms, Lung function defects.

INTRODUCTION

Industrial ambient air particulate matter inhaled in the workplace has been reported to cause a variety of health hazards (Beckett, 2000). Exposure to wood dust has been associated with respiratory health problems involving the upper and lower respiratory tract (Bean, *et al*., 2006; Meo, 2006). Different respiratory health problems have been associated with different tree species (Campbell, 2006; Pontier *et al.,* 2002). The wood industry in Ghana processes a mixture of different hardwood species, which could be potentially dangerous to the respiratory health of the exposed workers. The absence of any study in Ghana to report on respiratory health effect of the various wood species is a serious challenge. The main aim of this study was to examine the effects of wood dust on indices of lung function and the correlation between duration of exposure and lung function indices of woodworkers located at the Accra Timber market in Ghana.

MATERIALS AND METHOD

Population

A cross sectional study design was used. The study subjects were all Ghanaian woodworkers (sawmill operators, carpenters, wood sellers and wood porters) who worked with local wood species at the Accra Timber Market and an age-

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matched control group made up of staff from the College of Health Sciences in Korle-bu, Accra. The study excluded subjects who had asthma, vertebral column and thoracic cage abnormalities as well as smokers. The study was carried out between May and October 2008.

Questionnaires

Subjects were sampled by answering a modified questionnaire on occupational and medical history from the Medical Research Council (UK) (1960). This was administered by interview in English and translated into Twi or Ga (Ghanaian local languages) where necessary by a common interpreter. The questionnaire was aimed at investigating respiratory disabilities and also to obtain information on occupational history, including exposure to other industrial pollutants apart from wood dust and possible confounding factors.

Lung function testing

Lung function test was performed to the American Thoracic Society (ATS) (2003) standard using the electronic spirometer Vitalograph Alpha (Vitalograph Ltd, U.K). Spirometry was carried out with the subject in standing position. Six lung function parameters; vital capacity (VC), forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), forced expiratory ratio (FER), peak expiratory flow rate (PEFR) and forced expiratory flow ($FEF_{25-75\%}$) were determined for all subjects.

All the tests were performed between the hours of 9.00-13.00 GMT to minimize diurnal variation (Glindmeyer *et al*., 1994). The precise technique in executing various tests for the study was based on the operational manual of the instrument, which was also calibrated daily and operated at an ambient room temperature of between 26-28^{o}C.

The age, sex, standing height and body weight of each subject was recorded. Predicted values of VC, FVC, FEV_1, FER, PEFR, and $FEF_{25-75\%}$ for age and body size for black populations were provided in the spirometer by the Vitalograph manufacturer.

Ambient air dust sampling

The ambient air particulate matter (PM_{10}) mostly wood dust within and outside the sawmills was measured using the Minivol Sampler assisted by technicians from the Environmental Protection Agency (EPA) Accra. Sampling was carried for 24 hours from 4 locations within the market.

DATA ANALYSIS

Lung Function Test

Data analysis was conducted using an unpaired t-test to compare lung function parameters (VC, FVC, FEV_1, FEV_1%, PEF, $FEF_{25-75\%}$) between the woodworkers and the control subjects. Analysis of variance (ANOVA) was used to compare lung function parameters between the different groups of woodworkers classified. A level of statistical significance was established at a p-value <0.05. All the results were expressed as mean ± standard error.

Each of the lung function indices were correlated against the duration of exposure. Linear regression (Pearson's *r*) was applied to assess the association between lung function indices and duration of exposure. Odds ratios were calculated to assess the risk levels of lung function impairment in wood workers. The data was analyzed by the statistical programme SPSS version 14.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

Demographic characteristics

A total of 150 male non-smoking wood workers were interviewed and recruited from the Accra Timber Market before completing a questionnaire for the study. In addition, a total of 120 apparently healthy subjects were interviewed and recruited from the College of Health Sciences, University of Ghana, Korle-Bu before completing a questionnaire for the control group. The response rate of 100% was achieved for the questionnaire in both study groups.

The ages of the wood workers ranged from 20 to 60 years, the mean age was 37.36 years (S.E ±1.03). The heights of the wood workers ranged from 151 to 184 cm, the mean height was 169.47 cm (S.E ± 0.07) and the weights ranged from 55 to 87 Kg, the mean weight was 72.25 Kg (S.E. ± 0.69). The ages of the control group ranged from 20 to 59 years with a mean age of 37.92 years (S.E ±1.14) and the heights ranged from 151 to 188 cm with mean height 169.33 cm (S.E ± 0.64). The weights ranged from 45 to 123 Kg with mean weight 70.26 Kg (S.E ± 1.32). There was no significant difference ($p>0.05$) between all the anthropometric data of the woodworkers and the controls. Table 1 shows the demographic characteristics of the woodworkers and controls.

Determination of ambient air particulate matter concentration

Ambient air particulate matter (PM_{10}) of diameter less than 10 µm concentrations was monitored at the Accra Timber Market. The particulate matter concentrations recorded at 4 sampling locations within the Timber market ranged from 194.4 - 708.3µg/m^3. The mean ambient air particulate matter concentration was 392.33µg/m^3. The Environmental Protection Agency (EPA) guideline concentration was 70µg/m^3.

Lung function tests

A total of 104 wood workers out of 150 subjects were able to perform the spirometry satisfactorily. The remaining 46 wood workers could not achieve the required respiratory blow; these were therefore excluded from the study. Similarly, 16 subjects from the control group did not perform the spirometry satisfactorily and were excluded from the study leaving 104 for analysis.

Table 2 shows the lung function parameters of wood workers and controls. There was a significant reduction ($p<0.05$) in the lung function parameters of the wood workers relative to the controls [VC (p-0.008), FEV_1 (p-0.001), FER (p-0.001), PEFR (p-0.000) and $FEF_{25-75\%}$ (p-0.002) except FVC (p-0.095)].

Respiratory defects and Odds Ratio analyses

Regarding the proportion of wood workers with ventilatory defects, wood workers had more lung function defects than controls as shown in Table 3. The woodworkers showed predominantly obstructive (37%) and restrictive (32%) ventilatory defects compared to the controls (22%) and (15%) respectively for obstructive and restrictive defects.

Table 1. Demographic characteristics of wood workers and controls

Parameter	Wood workers Mean ± SEM n =104	Controls Mean ± SEM n =104	*p* value
Height (cm)	169.47± 0.70	169.33 ± 0.64	0.880 (NS)
Weight (Kg)	72.25 ± 0.69	70.26 ± 1.32	0.182 (NS)
Age (yr)	37.36 ± 1.03	37.92 ± 1.14	0.713 (NS)

* p-value < 0.05= significant, NS- not significant

Table 2. Lung function parameters of woodworkers and controls

Parameter	Woodworkers mean ± SEM n =104	Controls Mean ± SEM n =104	*p* value
VC (L)	3.32 ± 0.06	3.55 ± 0.06	0.008*
FVC (L)	3.46 ± 0.08	3.63 ± 0.07	0.095 (NS)
FEV_1(L)	2.58 ± 0.07	2.90 ± 0.06	0.001*
FER (%)	73.12 ± 2.03	79.13 ± 1.01	0.001*
PEFR(Ls^{-})	305.43 ±13.13	392.3 ± 11.3	0.000*
$FEF_{25-75\%}$ (L)	2.52 ± 0.11	3.00 ± 0.10	0.002*

* p-value < 0.05 = significant, NS-not significant

Table 3. Proportions of woodworkers and controls with lung function defects

Lung Function defect	Woodworkers n (%)	Controls n (%)	OR	95% CI
Restrictive	29(32)	11(15)	2.60	1.19 - 5.64
Obstructive	34(37)	16(22)	2.10	1.04 - 4.19
Combined	20(22)	7(9)	1.15	0.55 - 2.41

*****Significant

Odds ratio (OR) analysis showed significantly higher odds of acquiring obstructive and restrictive defects for woodworkers than for controls. These odds were statistically significant (95% CI). Combined defect also showed a difference in odds ratio, but this did not reach statistical significance (95% CI 0.55-2.41).

The exposed group was subjected to further statistical analysis in relation to relative risk (RR) of acquiring lung defect in relation to how long they have been working as woodworkers (duration of work). The results are presented in Table 4. As shown, longer-duration workers had higher percentage lung defects, with corresponding higher relative risk of acquiring lung defect than shorter-duration workers, although statistically non-significant at 95% CI.

DISCUSSION

This is a study of lung function tests of wood workers from Accra Timber Market and their age-matched controls with no history of exposure to wood dust. Absence of significant differences between the anthropometric parameters of wood workers and controls minimized the confounding effect due to these variables. The study did not include smokers and subjects with chest deformities.

This study showed a significant reduction in VC, FEV_1 FER, PEFR, and $FEF_{25-75\%}$ in the woodworkers relative to the controls which is consistent with previous findings in hardwood workers (Ige and Onadeko, 2000; Bosan and Okpapi, 2004; Okwari, *et al*., 2005). More woodworkers were found to have lung function indices below normal values relative to the controls. Seventy-four percent of woodworkers had PEFR values below normal, which agrees with observations made by Meo, (2006).

The decline in lung function indices in the woodworkers is attributed to the inhaled high particulate matter (mostly wood dust) concentration in the ambient air and it reflects the number of woodworkers having lung function defects. The physical activities involved in woodwork coupled with absence of protective devices increased workers' exposure to respirable wood dust.

The present study with relatively high cumulative wood dust exposure has shown a significant negative correlation ($p < 0.05$), as obtained in the statistical analysis, of increasing total cumulative exposure to respirable dust in the sawmills on the means of FVC, FEV1, FER and PEFR (%predicted).

The increasing duration of exposure to wood dust decreases lung function indices and increases lung function defect in the woodworkers. This is in agreement with the results observed by Okwari, *et al*., (2005) and Meo, (2006). However, relative risk analysis between duration of exposure to wood dust and lung function parameters observed in this study showed a non-significant link between them, unlike that reported by Moe's (2006) which showed a strong association.

Obstructive ventilatory defects were characterized by reduction in FER below normal predicted values (75%) (Pellegrino, *et al*., 2006). This definition identified 16% of wood workers and 3% of controls with an obstructive ventilatory defect in the study.

Table 4. Association between duration of work and lung function defects

Lung Function defect	Long term n (%)	Short term n (%)	RR	95% CI
Restrictive	25(30)	2(13)	3.46	0.72 - 4.55
Obstructive	30(37)	3(20)	2.86	0.74 – 5.01
Combined	20(24)	1(7)	5.38	0.66 – 3.67

The odds of predicted lung function among woodworkers exposed to wood dust

Lung function parameters	Odd Ratio	95% CI	P-values
FEV1 % predicted	0.15	(0.27, 0.90)	0.02
FER % predicted	0.09	(0.04, 0.49)	<0.01
FEF % predicted	0.12	(0.16, 0.68)	<0.01

Table 5. Comparison of lung function parameters between different woodworkers

Parameters (%)	Mean ± SE operators	Mean ± SE wood porters	Mean ± SE carpenters	Mean ± SE wood sellers	p-value
VC	83.31±1.73	81.69±3.50	79.79±2.36	82.96±2.06	0.05*
FVC	89.67± 2.65	90.69±4.09	85.14±4.36	92.31±2.50	0.25
FEV_1	78.78± 3.29	76.50±4.82	82.21±5.51	80.92±4.07	0.00*
FER	88.76± 3.45	86.06±3.30	95.36±5.83	93.73±2.89	0.01*
PEFR	64.71± 4.08	57.13±9.21	67.57±6.49	66.62±4.74	0.00*
$FEF_{25-75\%}$	65.22± 4.27	57.75±6.67	74.21±6.89	66.50±4.27	0.00*

* p-value < 0.05

		Lung function parameters below normal		
parameters	Normal**	Number of Woodworkers (%) n=104	Number of Controls (%) n=104	p-value
VC	80%	37(34)	23(22)	<0.01*
FVC	80%	22(20)	12(12)	<0.01*
FEV_1	80%	39(36)	23(22)	<0.01*
FER	75%	17(16)	3(3)	<0.01*
PEFR	80%	77(71)	44(44)	<0.01*
$FEF_{25-75\%}$	50%	30(28)	12(12)	<0.01*

This observation agrees with other previous studies reported in wood workers (Shamssain, 1992; Ige and Onadeko, 2000; Okwari, *et al*., 2005). The observed obstructive ventilatory defect is also attributed to allergic and non allergic reactions caused by wood dust. These reactions result in inflammatory changes and over-secretion of mucus in the airways causing reduction in the airway diameter. These further result in a disproportionate reduction of maximal airflow from the lungs in relation to the maximum volume that could be expelled (Pellegrino, *et al*., 2006).

This study did not perform reversibility tests with bronchodilators to confirm the presence of occupational asthma and chronic obstructive pulmonary diseases (COPD) among those workers with obstructive defect.

The restrictive ventilatory defects were defined as reduction in the VC value below the normal (80%) and normal or increased FER value (Pellegrino, *et al*., 2006). In all, 34% of wood workers and 22% of controls showed restrictive ventilatory defects. The presence of restrictive ventilatory defect in this study is consistent with previous studies (Shamssain, 1992; Mandryk *et al.,* 1999; Okwari, *et al*., 2005). The observed restrictive ventilatory defect may be attributed to inflammatory changes caused by the presence of wood dust lung parenchyma, a condition that could cause oedema and fibrosis of lung tissue, hence a reduced VC (West, 1990; Pellegrino, et al., 2006).

This study also showed combined ventilatory defects which were defined as a combination of obstructive and restrictive defects. Twenty-two percent of the woodworkers and 9% of the controls showed combined ventilatory defect. A lung function defect risk assessment made using odds ratios showed wood workers were at greater risk of lung function defects than controls.

The proportion of wood workers with obstructive ventilatory defect increased from less than 5 years to more than 14 years of exposure to wood dust; however, this decreased in wood workers who had been exposed for 15 years and above. Similarly the proportion of restrictive ventilatory defect increased from less than 5 years to 9 years, but started to decrease in workers with more than 10 years of exposure.

Although there appears to be an association between lung function defect and the duration of exposure in this study, the association was not consistent. The inconsistency could be attributed to the few numbers of woodworkers in this study

having lung function parameters above the normal values and perhaps the wood workers in later years changed their work from areas of higher concentration to a lower concentration of wood dust. Rosenberg and Gervais, (1989) and Shamssain, (1992) in their studies reported increased obstructive defects with increased duration of exposure. However, Shamssian, (1992) reported of a decline after 12 years of exposure.

In contrast Vedal, *et al*., (1986) and Bosan and Okpapi, (2004) reported of lung function defects increasing with degree of exposure, but not duration of exposure to wood dust. This contrast could possibly be attributed to the different health effects produced by different wood species, a possibility this study did not pursue.

Comparing the lung function indices between different categories of wood workers, machine operators and the wood porters showed greater reduction in the mean FEV1, FER, PEFR and $FEF_{25-75\%}$ than the other woodworkers. This observation is similar to the findings of Bosan and Okpapi, (2004). The differences observed in these parameters are attributed to the nature of their work, which involved greater physical activity than other workers and hence increased ventilation rate. This allows greater volume of inhaled air to bypass the cleansing nasopharynx and hence increased the exposure of the lower airways to the wood dust. In addition, their proximity to wood dust sources exposed them to greater concentration of wood dust than other workers (Breckett, 2000). These contributed to the higher proportions of machine operators and wood porters having obstructive ventilatory abnormalities

In conclusion, this study has shown that the woodworkers at the Accra Timber Market have impaired respiratory function and high lung function defects which are related to the high ambient air particulate matter concentration due to wood dust and absence of protective devices. Moreover, the lung function declines with duration of exposure to wood dust.

Measures to decrease ambient air particulate matter concentration due to wood dust and indeed other forms of ambient air pollution through EPA monitoring and a policy to regulate workplace hazards are advocated.

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