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Pulmonary function and symptoms in workers exposed to wood dust

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Abstract

Background **Exposure to wood dust can cause a variety of lung problems, including chronic airflow obstruction.**

Methods **Forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), forced expiratory ratio (FEV_1/FVC × 100), forced expiratory flow (FEF), forced mid expiratory flow (FMF), peak expiratory flow (PEF), and respiratory symptoms (cough, phlegm, breathlessness, wheezing, and nasal symptoms) were recorded in 145 non-smoking workers (77 male, 68 female) exposed to wood dust in a furniture factory in Umtata, Republic of Transkei, and 152 non-smoking control subjects (77 male, 75 female) from a bottling factory with a clean environment.**

Results **After adjustment for age and standing height the forced expiratory indices were significantly lower in the exposed male workers than in the control subjects. FEF and PEF in the exposed men were 81·3% and 89·4% of predicted values and were lower than other indices. FVC in exposed men showed a significant inverse correlation with exposure (expressed in number of years of employment). The FVC was reduced by 26 ml per year of employment. The proportion of men with an FEV_1/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.**

Conclusion **Workers exposed to pine and fibre dust have more respiratory symptoms and a greater risk of airflow obstruction.**

Many industrial activities are associated with some kind of occupational hazard that can cause injury in an insidious manner. The adverse effects of exposure to wood dust include nasal carcinoma, allergic and irritant cutaneous and respiratory reactions, and chronic respiratory impairment.[1] Workers exposed to western red cedar dust are more likely to develop occupational asthma.[2,3] Vedal *et al*[4] found a reduction in forced vital capacity (FVC) and forced expiratory volume in one second (FEV_1) and a higher incidence of chronic cough, dyspnoea, and persistent wheeze in exposed wood workers. They found that the symptoms of work related asthma were more common after 10 years of exposure and the levels of pulmonary function were lower with higher wood dust exposure. Wood workers reported more nasal and eye symptoms and more cough, sputum, and wheezing than control subjects and there was a significant decline in lung function over the work shift. An inverse correlation between baseline lung function and an exposure index (mean area dust level multiplied by length of exposure) has been found in wood workers.[5] A higher prevalence of respiratory impairment was found in exposed wood workers in sawmills[6]; among the sawmill workers a high percentage of workers (28·4%) suffered from lung restriction resulting from inhalation of wood dust produced during the cutting of soft woods on sawing machines.

Occupational asthma has been caused by iroko wood and exposure to ash wood dust (*Fraxinus americana*) in single case reports.[7,8] Industrial exposure of wood workers to formaldehyde causes transient impairment of lung function over a work shift, with a cumulative effect over the years. The impairment can be reversed by four weeks without exposure.[9]

Exposure to wood dust may cause various diseases, including extrinsic allergic alveolitis, the organic dust toxic syndrome, occupational asthma, non-asthmatic chronic airflow obstruction, and simple chronic bronchitis (mucus hypersecretion). Of these, simple chronic bronchitis and non-asthmatic chronic airflow obstruction occur most often. The level and pattern of disease varies with the type of wood dust, climatic conditions, and the manner in which it is handled, being particularly influenced by the use of fungicides.[10]

The purpose of the present study was to establish any possible detrimental effect of exposure to wood dust on respiratory function in wood workers in the Transkei. This is the first study on wood workers to use a detailed respiratory questionnaire.

Methods

SUBJECTS

The study was carried out on the 145 non-smoking workers (77 male, 68 female) exposed to wood dust at the raw materials store and the breakdown mill wood section of a furniture firm in Umtata, Transkei (a small independent homeland in Southern Africa on the Indian Ocean with a population of 4 million Xhosa speaking blacks). The 152 non-smoking work-

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ers (77 male, 75 female) in a pollution free bottling firm in the same city served as controls. The excluded smokers (all male) numbered 18 (10% of the exposed men) at the furniture firm and 21 (12% of the male workers) at the bottling firm. Among the exposed workers 20% were working with pine wood, and 80% with medium density board fibre wood. All subjects were black Africans of the same socioeconomic status and with similar levels of activity.

The predicted values of forced expiratory indices were derived from equations from our previous studies (unpublished) on normal black Southern African adults.

MEASUREMENTS

Forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), forced expiratory ratio ($FEV_1/FVC \times 100$), forced expiratory flow between the first 200 ml and 1200 ml of FVC (FEF 200–1200), forced mid expiratory flow between 25% and 75% of FVC (FMF), and peak expiratory flow (PEF) were recorded with the Vitalograph compact spirometer (Vitalograph Inc). A nose clip was used and all volumes were corrected to BTPS. The spirometer was calibrated with a 1 litre precision syringe (Vitalograph Inc). The same equipment and observer were used for all subjects and the recordings were made between 8 am and 4 pm over three months. Only recordings that satisfied the validity test of Segall and Butterworth,[11] which takes into account the maximal mid expiratory flow time, were considered; and the result for the best of three attempts was used. The best curve was the one that produced the highest FEV_1, provided that the FVC was within a small percentage of the subject's best FVC.

A modified version of the respiratory questionnaire of the British Medical Research Council's Committee on the Aetiology of Chronic Bronchitis[12] was used to record respiratory symptoms (cough, phlegm, breathlessness, wheezing, and nasal symptoms). A local technician carried out the interviews in the Xhosa language. The permission of the local ethical committee was obtained.

Total dust concentration in the factory was measured by the Gil-Air Sampling System (35 Fairfield Place, West Caldwell, New Jersey 07006–6206, USA). The duration of sampling was eight hours and the pumps and the filters of the personal samplers were put at different sites in each section and exposed to continuous currents of air.

Age was recorded from the subject's birth certificate to the nearest six months. Standing height was measured with a standard anthropometric scale attached to the body weight scale.

ANALYSIS

The data were analysed by means of multiple regression of separate lung function measurements on the independent variables sex, age, height, and exposure time. Differences between the exposed and the control group were compared by unpaired *t* tests and multiple regression analysis. Calculations were performed with the Statgraphic computer program.[13]

Table 1 Mean (SD) anthropometric and spirometric variables in men

	Exposed	*Control*	*p*
n	77	77	
Age (y)	34·92 (7·24)	33·77 (6·44)	NS
Height (cm)	167·41 (7·29)	167·97 (6·92)	NS
Weight (kg)	65·98 (11·75)	69·19 (10·75)	NS
Respiratory values [% predicted*]			
FVC (l)	3·64 (0·75) [93·2]	4·14 (0·71) [103·4]	<0·001
FEV_1 (l)	2·65 (0·68) [90·4]	3·20 (0·54) [106·3]	<0·001
FEV_1/FVC	73·19 (6·81) [99·1]	77·64 (8·64) [104·7]	<0·01
FMF (l/s)	3·09 (1·71) [101·9]	3·68 (1·34) [117·0]	<0·01
FEF (l/s)	4·94 (1·54) [81·3]	7·06 (2·43) [113·6]	<0·001
PEF (l/s)	6·14 (2·06) [89·4]	7·92 (2·46) [112·6]	<0·001
Exposure (y)	13·83 (8·56)		

*Derived from equations from our unpublished studies on normal black Southern African adults.
FVC—forced vital capacity; FEV_1—forced expiratory volume in one second; FEV_1/FVC—forced expiratory ratio; FMF—forced mid expiratory flow between 25% and 75% of FVC; FEF—forced expiratory flow between the first 200 ml and 1200 ml of FVC; PEF—peak expiratory flow; NS—$p > 0.05$.

Table 2 Mean (SD) anthropometric and spirometric variables in women

	Exposed	*Control*	*p*
n	68	75	
Age (y)	32·27 (9·75)	33·69 (3·65)	NS
Height (cm)	156·83 (6·34)	156·68 (5·93)	NS
Weight (kg)	67·32 (12·78)	72·65 (13·81)	<0·01
Respiratory values [% predicted*]			
FVC (l)	2·94 (0·65) [97·9]	2·99 (0·62) [100·9]	NS
FEV_1 (l)	2·25 (0·41) [95·4]	2·35 (0·48) [100·0]	NS
FEV_1/FVC	77·88 (9·01) [101·4]	78·66 (8·26) [102·8]	NS
FMF (l/s)	2·53 (0·96) [95·3]	2·71 (0·92) [104·2]	NS
FEF (l/s)	4·39 (1·61) [102·4]	4·62 (1·42) [109·4]	NS
PEF (l/s)	5·33 (1·62) [104·8]	5·47 (1·39) [108·6]	NS
Exposure (y)	6·87 (1·86)		

*Derived from equations from our unpublished studies on normal black Southern African adults.
For abbreviations see table 1.

Table 3 Prevalence of an FEV_1/FVC ratio of less than 70 and of 70 or more in the exposed and control workers

No (%) of workers			
Exposed		*Control*	
FEV_1/FVC		*FEV_1/FVC*	
<70	*≥70*	*<70*	*≥70*
44 (30·3)	99 (68·2)	55 (17·4)	249 (78·8)

Table 4 Prevalence of an FEV_1/FVC ratio of less than 70 and of 70 or more in the exposed workers with different durations of employment

	No (%) of workers	
	FEV_1/FVC	
Years of employment	*<70*	*≥70*
1–9	31 (26·7)	85 (73·3)
10–19	9 (56·2)	6 (37·5)

Results

After adjustment for age and standing height the exposed men had significantly lower forced expiratory indices than the control subjects ($p < 0·001$) (table 1). This was not the case with the exposed women; there was no significant difference in forced expiratory indices between the exposed women and the control women (table 2). FEF and PEF in the exposed men were 81·3% and 89·4% of predicted values and were lower, in terms of % predicted, than the other indices.

After adjustment for standing height and age, FVC in exposed males showed a significant inverse correlation ($p < 0·01$) with exposure measured in number of years of employment. Forced expiratory indices in the exposed women did not show any correlation with exposure.

The mean (SD) total dust concentration in the factory was 3·82 (1·34) mg/cm^3.

The proportion of subjects with an FEV_1/FVC below 70 was significantly higher ($p < 0·01$) in the exposed workers than in the control subjects (table 3) and it was significantly higher ($p < 0·01$) in the exposed workers with more years of employment (table 4). The multiple regression equation for FVC and exposure in the exposed men is:

$$FVC\,(l) = 4·203 - 0·010\,\text{AGE}\,(y) - 0·026\,\text{EXPOSURE}\,(y)$$

or

$$FVC\,(l) = 0·444 - 0·009\,\text{AGE}\,(y) + 0·022\,\text{HEIGHT}\,(cm) - 0·025\,\text{EXPOSURE}\,(y),$$

indicating about 26 ml decline in FVC per year of exposure.

The exposed workers showed a significantly higher prevalence of respiratory symptoms than the control subjects (table 5). The prevalence of nasal symptoms (49%), cough (43%), and phlegm (15%) was very high in the exposed workers. The prevalence of respiratory symptoms increased with the increase in the number of years of employment (table 6). Cough and nasal symptoms showed a pronounced increase with years of employment. Exposure beyond 12 years is not included in the table because the sample size was small and this affected the consistency of increase in the prevalence of respiratory symptoms with exposure time.

Discussion

In this cross sectional study we confirmed previous findings[3–6 14] that exposure to wood dust is associated with respiratory illness. The workers exposed to wood dust and the control subjects working in a good, clean, pollution free environment were matched closely for age, height, and weight. The differences in pulmonary function and respiratory symptoms in the exposed men are likely therefore to be attributable to their exposure to wood dust. Both male and female workers were exposed acutely to wood dust as we did not consider workers from other sections of the factory (that is, steel, spray, and painting sections). The female workers who were exposed did not show

Table 5 Percentages of woodworkers and controls with respiratory symptoms

	Question	*Exposed group*	*Control group*	*p*
1	Do you usually COUGH in the morning in winter?	40·6	23·7	<0·01
2	Do you usually COUGH during the day or at night, in winter?	43·4	28·9	<0·01
3	Do you COUGH on most days for as much as three months each year?	5·5	2·1	NS
4	Do you bring up PHLEGM on arising in the morning in winter?	24·1	10·5	<0·05
5	Do you bring up PHLEGM twice or more during the day or at night in winter?	17·9	10·6	NS
6	Do you bring up PHLEGM on most days or nights as much as three months each year?	15·2	9·4	NS
7	Have you had a period of increased COUGH and PHLEGM lasting for three weeks or more in the past three years?	13·8	8·6	NS
8	Have you ever COUGHED up blood?	6·9	2·8	NS
9	Are you troubled by SHORTNESS OF BREATH when hurrying on level ground or walking up a hill?	17·9	10·3	NS
10	Do you get SHORT OF BREATH when walking with other people of your age on level ground?	17·9	10·7	NS
11	Do you have to STOP FOR BREATH when walking at your own pace on level ground?	18·7	5·7	<0·05
12	Does your chest ever sound WHEEZING or whistling?	12·8	4·8	<0·05
13	Does your chest sound WHEEZING on most days or nights?	10·3	3·9	<0·05
14	If your answer to 13 was "yes," was your breathing absolutely normal between attacks?	11·7	7·8	NS
15	Do you usually have a STUFFY NOSE or CATARRH at the back of your nose in winter?	49·6	18·7	<0·01

NS—p > 0·05.

Table 6 Percentages of woodworkers with respiratory symptoms by duration of employment

Question	Years of employment		
	1–4 (n = 94)	5–8 (n = 17)	9–12 (n = 18)
1 Do you usually COUGH in the morning in winter?	35	58	66
2 Do you usually COUGH during the day or at night, in winter?	37	58	72
3 Do you COUGH on most days for as much as three months each year?	3	6	11
4 Do you bring up PHLEGM on arising in the morning in winter?	21	23	16
5 Do you bring up PHLEGM twice or more during the day or at night in winter?	16	17	22
6 Do you bring up PHLEGM on most days or nights as much as three months each year?	15	23	16
7 Have you had a period of increased COUGH and PHLEGM lasting for three weeks or more in the past three years?	13	29	16
8 Have you ever COUGHED up blood?	3	23	11
9 Are you troubled by SHORTNESS OF BREATH when hurrying on level ground or walking up a hill?	12·7	29	22
10 Do you get SHORT OF BREATH when walking with other people of your age on level ground?	11·7	29	22
11 Do you have to STOP FOR BREATH when walking at your own pace on level ground?	12·7	29	22
12 Does your chest ever sound WHEEZING or WHISTLING?	8·5	29	11
13 Does your chest sound WHEEZING on most days or nights?	7·4	29	11
14 If your answer to 13 was "yes," was your breathing absolutely normal between attacks?	7·4	35	11
15 Do you usually have a STUFFY NOSE or CATARRH at the back of your nose in winter?	49	47	55

a significant reduction in their forced expiratory indices, presumably because they were less exposed than the exposed men; female workers did less dusty work.

After adjustment of the forced expiratory indices for age and height, FVC in men was the only index which showed a significant correlation with exposure expressed as the number of years of employment.

The presence of airflow obstruction in the wood workers in the present study supports the results of earlier studies.[3–6] The proportion of workers with an FEV_1/FVC ratio below 70 was almost double the number in the control subjects. Moreover, the proportion of subjects with an FEV_1/FVC ratio below 70 in the exposed workers who had been employed for at least 10 years was double the number in the exposed workers with less than 10 years' employment. These findings, taken with the significantly lower values of FEF and PEF in exposed men, indicate that exposure to wood dust in these workers has a serious effect on respiratory function.

Our study is the first to use a detailed respiratory questionnaire in wood workers. The prevalence of cough in the morning (40%) and during the day or at night (43%) in the exposed workers was higher than in other studies.[4 5 14] The prevalence of phlegm (15%) in our workers was higher than in the study by Chan-Yeung *et al*[14] but lower than in the study by Vedal *et al*.[4] The prevalence of shortness of breath (18%) was greater than in one previous study,[5] similar to that in another,[14] and lower than that in a third.[4] Wheezing (13%) in our exposed workers occurred more often than in one study[14] but less often than in the two other studies.[4 5]

Nasal symptoms (50%) occurred more often in our workers than in previous studies.[4 5] This discrepancy may be explained by the higher level of dust in our industry and the type of wood that is handled by our workers—especially fibre wood, which generated 80% of the dust.

We conclude from this study that workers exposed to pine and fibre wood dust have more respiratory symptoms than control subjects and that such exposure increases the risk of airflow obstruction.

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