Lung function of Zimbabwean farm workers exposed to flue curing and stacking of tobacco leaves

E E Osim, C T Musabayane, J Mufunda

Objectives. To perform lung function tests on tobacco farm workers (TFWs) chronically exposed to flue curing and stacking of tobacco leaves and to compare them with vegetable farm workers (VFWs) who were not exposed to any known air pollutant (control).

Design. Comparative study.

Setting. Tobacco and vegetable farms.

Subjects. 20 TFWs and 30 VFWs. All subjects were male and the mean age, height and weight of the two groups were not significantly different.

Outcome measures. Lung function indices.

Results. Forced vital capacity (FVC), forced expiratory volume in 1 second (FEV_1) and peak expiratory flow rate (PEFR) of the TFWs were 3.28 ± 0.51 litres, 2.68 ± 0.74 litres and 6.41 ± 2.08 litres/second, respectively. These figures were significantly lower than 3.97 ± 0.83 litres, 3.09 ± 0.71 litres and 8.62 ± 2.74 litres/second, respectively, for the control subjects ($P < 0.01$, 0.05 and 0.01, respectively). However, mean FEV_1 as a percentage of the FVC (FEV_1%) of the TFWs was not significantly different from that of the controls. FVC of the TFWs declined with duration of service ($r = 0.74$; $P < 0.01$).

Conclusion. The results are indicative of restrictive lung defect in the TFWs and may be attributed to long-term exposure to flue curing and stacking of tobacco leaves. The results also suggest the importance of the duration of exposure in the aetiology of lung impairment in this environment.

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Department of Physiology, University of Zimbabwe, Harare
E E Osim, BSc Hons, MSc, PhD
C T Musabayane, BSc Hons, PhD
J Mufunda, MB ChB, PhD

Exposure to tobacco smoke impairs lung function.[1,2] Most studies have focused on both active and passive tobacco-smoking habits.[1-7] The effects of passive cigarette smoking on health have not been taken as seriously as the effects of active smoking, especially in the developing world, despite considerable literature in this regard. Many studies report on the effects of smoking during pregnancy on the unborn child. These studies have reported an increased risk of sudden infant death syndrome, low birth weight and respiratory illness.[3,4] In addition postnatal exposure to passive smoking has been found to be responsible for increased risk of acute respiratory illness and morbidity.[5-7]

In many tobacco-exporting nations, including Zimbabwe, there is occupational exposure to flue curing of tobacco leaves. This process involves drying fresh tobacco leaves in barns — coal or firewood is burned outside the barns and the hot air generated is passed over the leaves in pipes. Tobacco farm workers (TFWs) assigned to flue curing frequently replace the dried tobacco leaves with fresh ones. Dry leaves are then stacked into bales for export. TFWs exposed to flue curing and stacking of tobacco leaves cough frequently and complain of tightness in the chest (personal observation). Despite this, there are no reports in the literature on the effects of occupational exposure to flue curing or drying of tobacco leaves on the lung function of workers. The aim of this study was, therefore, to find out the ventilatory status of TFWs exposed to flue curing and stacking of tobacco leaves into bales and to compare their values with those of vegetable farm workers (VFWs) who are not exposed to any known air pollutant.

Materials and Methods

Subjects and workplace

Two groups of subjects were studied, namely 20 TFWs exposed to flue curing and stacking of tobacco leaves, and 30 VFWs who were used as a control group. The two groups of subjects were matched for sex, age, height, weight and smoking habits (Table I).

Tobacco farm workers (TFWs)

The TFWs were all male Zimbabweans who were engaged in flue curing and stacking of tobacco leaves for about 6 months of each year (January - June). Ten of them were engaged in flue curing and the other 10 were engaged in stacking of tobacco leaves into bales. Furthermore 10 of the TFWs were casual labour only hired for the flue-curing season, while the other 10 were permanent farm labour. They had all been in the business of flue curing for more than 3 years. All 20 workers engaged in the curing and stacking of tobacco leaves were from two commercial farms about 20 km apart in the same district. There were no women engaged in the two enterprises. Barns where the tobacco leaves were hung for the drying process were hot, humid and choking, with no fans to improve ventilation. There were also no vacuum extractors to minimise dust particles in the barns or in the room where dried tobacco leaves were pressed into bales for export. The TFWs wore no face masks to minimise the inhalation of respirable dust particles. The age and height ranges of the workers were 27 - 46 years, and 157 - 180 cm, respectively. Their body weight range was 57 - 71 kg. There were only two tobacco smokers, constituting 10% of the group (Table I).

Table I. Comparison of ventilatory function indices and anthropometric parameters for TFWs and control subjects

Ventilatory function indices and anthropometric parameters	TFWs ($N = 20$)	Control subjects ($N = 30$)	Level of significance
FVC (litres)	3.28 ± 0.51	3.97 ± 0.83	‡
FEV_1 (litres)	2.68 ± 0.74	3.09 ± 0.71	*
FEV_1%	80.45 ± 17.2	78.55 ± 8.86	NS
PEFR (l/sec)	6.41 ± 2.08	8.62 ± 2.74	†
Age (yrs)	33.70 ± 5.20	30.32 ± 8.97	NS
Height (cm)	167.30 ± 6.53	167.68 ± 6.30	NS
Weight (kg)	59.60 ± 5.94	59.12 ± 7.05	NS
No. of smokers	2	3	

* $P < 0.05$.
† $P < 0.01$.
‡ $P < 0.001$
NS = not statistically significant.

Vegetable farm workers (control group)

The control group consisted of male VFWs who were not exposed to any known air pollutant and had no history of respiratory disease. The age, height and weight range of the VFWs were 18 - 46 years, 158 - 184 cm, and 48 - 74 kg, respectively. Ten workers were involved in field irrigation, 15 in vegetable packaging, 2 were in security, 2 were drivers and 1 was a clerk. None of the VFWs was exposed to pesticides or herbicides. They had been in the permanent employment of a private farm for more than 3 years, their work environment was clean, and there was no evident environmental pollution. Only 3 workers (10%) were tobacco smokers.

Gravimetric dust sampling

A gravimetric dust sampler (type Hund umweltmesstechnik, manufactured by Drager, Germany) was used for dust sampling on the tobacco and vegetable farms. The instrument measures the concentration of dust in the respirable range as it maintains a constant supply of air at 2 litres/minute through its filter.

Lung function indices

The ventilatory function indices, namely forced vital capacity (FVC), forced expiratory volume in 1 second (FEV_1), forced

expiratory volume in 1 second as a percentage of the FVC (FEV_1%), and peak expiratory flow rate (PEFR), were measured to assess ventilatory (lung) function. The vitalograph spirometer (Medicor Budapest, type MS-11) was used for the measurement of all the lung function indices. It was not feasible to measure the diffusion capacity and blood gases of these workers owing to technical problems. However, the measured parameters, namely FVC, FEV_1, FEV_1% and PEFR, were sufficient to detect obstructive ventilatory defect, restrictive ventilatory defect, and a mixed pattern of both obstructive and restrictive ventilatory defects.

Test procedure

Subjects were called in groups and instructed as to the procedure of the tests. To facilitate understanding of the test procedures, demonstrations of the tests were performed and questions entertained. After the group instruction, subjects were called into the test room individually. A modified British Medical Council respiratory disease questionnaire was completed before the tests were performed. The questionnaire was used to record the name, sex, age, type of job, smoking habits, duration of service and any history of cardiopulmonary diseases in the subjects; height without shoes and weight with light clothing were measured and recorded. All the measurements of the TFWs were taken on the same day by one investigator, as were measurements of the VFWs. This was done to keep to a minimum errors which may be caused by different investigators and day-to-day variations. Forced expiratory spirograms were measured according to the method described by Osim *et al.* in a previous study.[8] The measurements met the standards of the American Thoracic Society.[9]

Statistical analysis

Differences were assessed using the Student's two-sample unpaired *t*-test. Data are presented as mean and standard deviation (SD). A *P*-value of less than 0.05 was considered significant.

RESULTS

Ventilatory function and anthropometric parameters of TFWs and control subjects

Table I summarises the ventilatory function indices, anthropometric parameters and smoking habits of TFWs and control subjects. FVC, FEV_1 and PEFR were significantly lower ($P < 0.01$, 0.05 and 0.001 respectively) in TFWs than in control subjects. FEV_1% was not statistically different in the two groups. Mean difference in FVC was 0.678 litres; 95% confidence interval (CI) –1.06 to –0.30. Mean difference in FEV_1 was 0.455 litres; 95% CI –0.88 to –0.03. Mean difference in PEFR was 2.210 l/s; 95% CI –33.59 to –0.83.

There were also no statistically significant differences in the mean age, height and weight of the TFWs and control group. The smoking habits of the two groups (10% for TFWs and control subjects) were also similar.

Ventilatory function and anthropometric parameters of two groups of TFWs and control subjects

Table II summarises the ventilatory function indices (FVC, FEV_1, FEV%, and PEFR), anthropometric parameters (age, height and weight) and smoking habits of the two groups of TFWs (workers exposed to the flue curing of tobacco and those exposed to stacking of tobacco leaves into bales). All the ventilatory function indices, anthropometric parameters and smoking habits of the two groups of farm workers were not significantly different from each other.

Table II. Comparison of ventilatory function indices and anthropometric parameters for TFWs exposed to flue curing with those exposed to stacking of tobacco leaves

Ventilatory function indices and anthropometric parameters	TFWs exposed to flue curing ($N = 10$)	TFWs exposed to stacking of tobacco leaves ($N = 10$)	Level of significance
FVC (litres)	3.29 ± 0.55	3.27 ± 0.49	NS
FEV_1 (litres)	2.67 ± 0.79	2.67 ± 0.73	NS
FEV_1%	80.36 ± 18.15	80.55 ± 17.22	NS
PEFR (l/sec)	6.40 ± 2.17	6.42 ± 2.12	NS
Age (yrs)	34.20 ± 4.57	33.20 ± 6.00	NS
Height (cm)	168.6 ± 6.04	166.0 ± 7.07	NS
Weight (kg)	61.3 ± 7.13	58.0 ± 4.06	NS
No. of smokers	1	1	

NS = not statistically significant.

Relationship between ventilatory function and duration of service of TFWs

Fig. 1 shows a correlation between FVC of TFWs and the duration of their service. The correlation was statistically significant ($r = -0.74$; $P < 0.01$). All the other ventilatory function indices (FEV_1, FEV_1% and PEFR) also declined with the duration of service, but were not statistically significant.

Relationship between FVC and age and height of TFWs

Figs 2 and 3 show the relationship between FVC of TFWs and their age and height, respectively. The relationships were not significant (FVC/age, $r = –0230$; $P > 0.05$); FVC/height, $r = 0.199$; $P > 0.05$).

Dust sampling

The concentration of respirable dust was 0 mg/m³ for all the sites on the vegetable farm where control subjects were chronically exposed. The total respirable dust concentrations

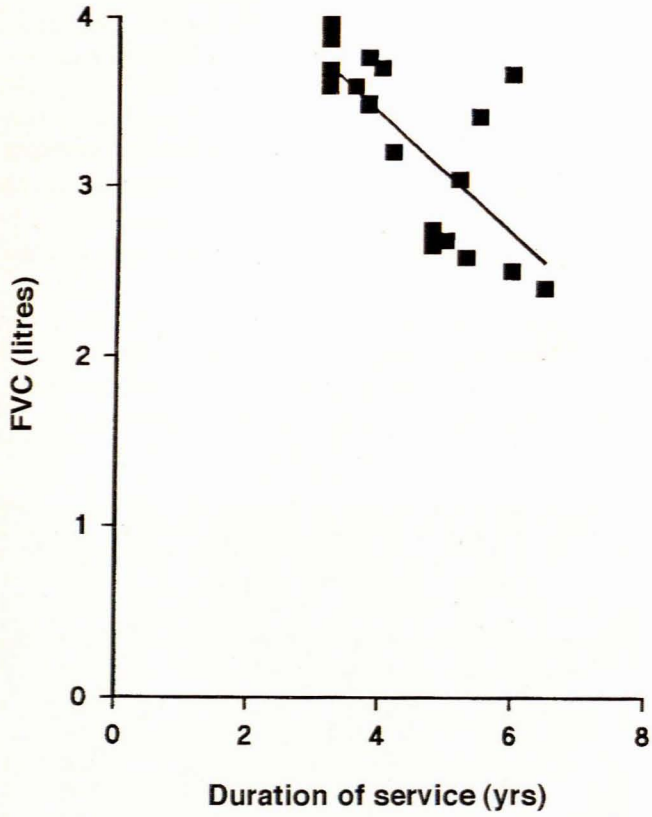

Fig. 1. Relationship between FVC and duration of service for TFWs exposed to flue curing and stacking of leaves (r = -0.74; P < 0.01).

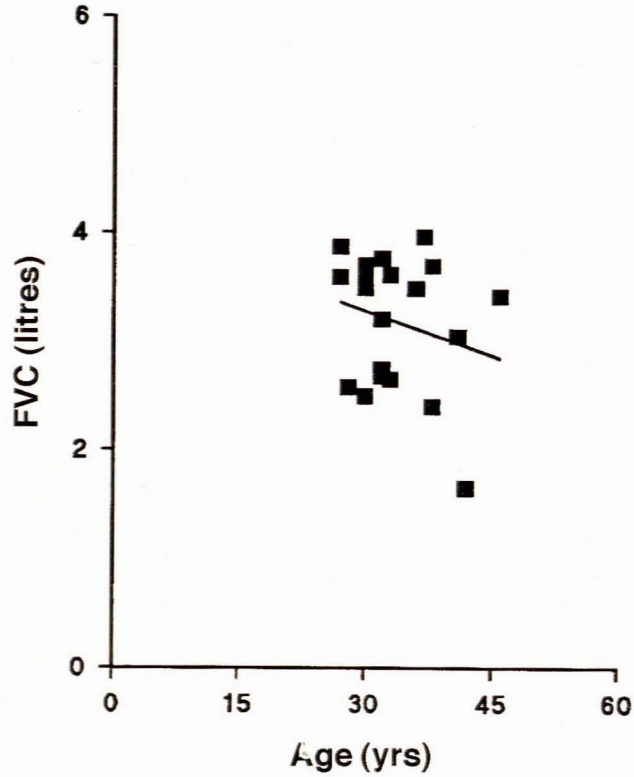

Fig. 2. Relationship between FVC and age of TFWs exposed to flue curing and stacking of tobacco leaves (r = -0.23; P > 0.05).

were between 8.0 and 30.5 mg/m³ (19.13 ± 10.82 mg/m³) for four sampling sites on the tobacco farm.

History of cardiopulmonary disease

There were no confirmed cases of pneumonia, pulmonary tuberculosis, asthma or bronchitis.

Discussion

This study found that occupational exposure to flue curing and stacking of tobacco leaves into bales impairs lung function. The anthropometric measurements of TFWs were not significantly different from those of VFWs used as controls. The smoking habits of both the TFWs and their control subjects were also similar, and none of the workers had any history of cardiopulmonary disease. Since the parameters that affect lung function were similar in the two groups of workers, the significant differences in the lung function indices between TFWs and their control subjects may be attributed to occupational exposure. FVC, FEV_1 and PEFR were significantly lower in the TFWs than in the control subjects. However,

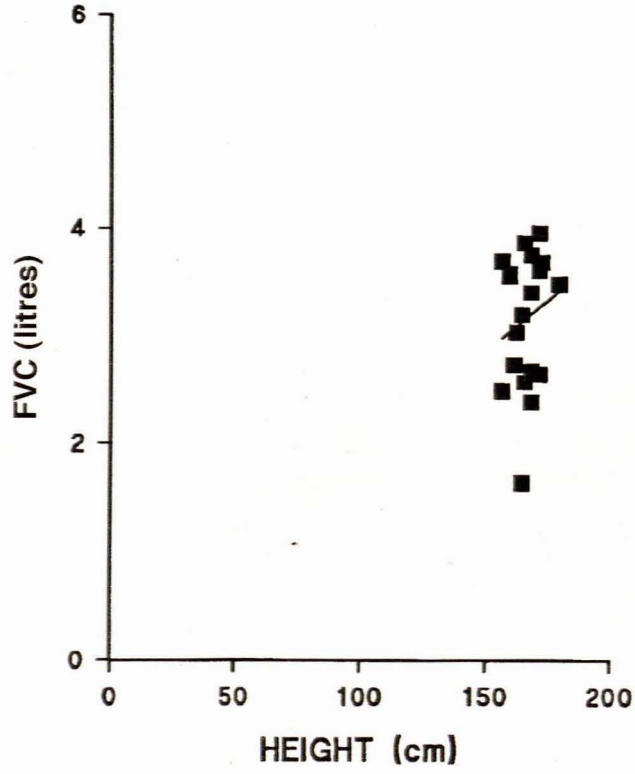

Fig. 3. Relationship between FVC and height of TFWs exposed to flue curing and stacking of tobacco leaves (r = 0.199; P > 0.05).

values of FEV_1% in the two groups were similar. These deviations are characteristic of restrictive ventilatory defect since in the latter FEV_1% is usually normal and FEV_1 and FVC are reduced.[10,11] Our results are similar to those obtained by other investigators who attributed lung function impairment to exposure to passive tobacco smoking, either at home or at work.[12] The causative agent may be tobacco dust since exposure to tobacco dust in cigar and cigarette factories has also been reported to produce lung function impairment,[13] which supports our finding. The dust level in the respirable range in the environment of flue curing and stacking of tobacco leaves was high. However, this does not rule out the possibility that other confounding causative factors, e.g. gases, humidity, etc., may also be responsible for the lung function deterioration.

It has been reported that smoke from unvented coal, kerosene or firewood stoves can also impair lung function.[14] In this instance it is not known whether smoke from unvented coal fires outside the barns had any significant effect on the observed decrease in lung function. However, the exposure to smoke from coal fires outside the barns was minimal as TFWs were more involved in the replacement of dry leaves in the barns and packaging the dry leaves into bales. The absence of any significant differences between the ventilatory function indices of the two groups of tobacco workers, i.e. those engaged in flue curing and those engaged in stacking of tobacco leaves into bales, may indicate that the level of exposure to the effect of tobacco was uniform throughout the environment. It may also rule out attributing observed lung function impairment exclusively to the hot, humid environment of flue curing, or to the occasional contact with coal fires outside the barns by those engaged only in flue curing.

The lung function of TFWs exposed to flue curing decreased with the duration of their employment (Fig. 1). The decrease was statistically significant for FVC only. There were no statistically significant relationships between FVC and age, or FVC and height (Figs 2 and 3). This controls for possible confounding effects of age or height as factors which may be responsible for the worsening of FVC. Decline in ventilatory function with duration of service suggests the importance of duration of exposure in the aetiology of lung diseases at the workplace. As such the lung function of farm workers will worsen with time. Fortunately flue curing and stacking of tobacco leaves into bales are seasonal occupations, which may give workers time to recover from the effects of exposure. Furthermore, although the reductions (12.5 - 22%) are significant, they do not suggest massive impairment of lung function, and the efficiency of the workforce has not yet been compromised. However, there was a high prevalence (40%) of unproductive cough that is common to extrinsic allergic alveolitis and organic dust pneumoconiosis, both of which fall under the general diagnosis of hypersensitivity and pneumonitis.[15]

There need be no fear of working in the environment of flue curing and stacking of tobacco leaves provided that the necessary precautionary measures are taken. Precautionary measures include the use of dust monitors to measure the levels of respirable and coarse dust in the environment; the wearing of face masks to minimise the inhalation of dust; vacuum dust extractors; protective overalls; and a clinic for frequent medical examination of the health of workers. Workers with impaired lung function should be redeployed to other less hazardous areas of the farm. In conclusion, chronic exposure to flue curing and stacking of tobacco leaves can impair lung function of workers. There is, therefore, a need to introduce precautionary measures in the abovementioned environment.

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