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SUPPORTED BY THE RESEARCH COUNCIL OF ZIMBABWE

Lung function status of some Nigerian men and women chronically exposed to fish drying using burning firewood

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Objective: To determine the lung function status of some Nigerian men and women chronically exposed to fish drying using burning firewood.

Design: Case control study.

Setting: Ibaka, Utaewa and Ikanga fishing settlements.

Subjects: 183 males and 192 females engaged in fishing, aged 20 to 45 years who have been exposed for a minimum of five years as cases. The control group comprised sex matched male (142) and female (152) Nigerians from the same area who were not exposed to any known air pollutant.

Main Outcome Measures: Lung function indices: FVC, FEV₁, FEV₁% and PEFr.

Results: Lung function indices were significantly lower in men engaged in fishing than in their controls: FVC [mean (SD): 2.98 (0.20) vs 3.52 (0.29), p<0.001]; FEV₁ [2.08 (0.18) vs 2.82 (0.25), p<0.001]; FEV₁% [69.8 (3.1) vs 80.2 (6.7), p<0.001]; and PEFr [335 (22) vs 592 (99), p<0.001], respectively. Similarly, lung function indices were lower in females in the fishing industry than in their controls: FVC [2.42 (0.17) vs 3.02 (0.24), p<0.001]; FEV₁ [1.70 (0.19) vs 2.55 (0.21), p<0.001]; FEV₁% [72.9 (3.2) vs 84.4 (6.7), p<0.001]; and PEFr [298 (22) vs 418 (34), p<0.001].

All the lung function indices (except FEV₁%) of the fishermen and women declined significantly (p<0.001) with their duration of exposure. The results showed a predominantly mixed pattern (restrictive and obstructive) of respiratory defect. There were higher prevalences of respiratory and other symptoms among the cases than the controls. The respiratory symptoms included cough with sputum, chest pain, dyspnoea, catarrh and sneezing and unproductive cough. Other symptoms were eye and skin irritation, internal heat and headache.

Conclusions: Chronic exposure to fish drying using burning firewood can impair lung function and cause respiratory and other symptoms.

Introduction

Fishing is one of the main occupations practised by the riverine people of southern Nigeria. Both males and females are actively engaged in this occupation with virtually all the age groups involved. Fish and other marine products are often preserved by freezing or drying. Owing to the high cost of freezing and unavailability of required facilities in the environment, most persons adopt fish drying as a method of preserving fish. Local fish drying involves exposure of fish to naked fire from firewood. The smoke and heat generated serve as a source for drying the fish gradually. This procedure

produces a lot of smoke and volatile components from the fish which are inhaled frequently by people engaged in fish drying over a long period.

Exposure to smoke is dangerous to health particularly pulmonary function.¹⁻³ Impaired lung function has been documented among cigarette smokers⁴⁻⁶ and fire fighters^{2,7} who are chronically exposed to smoke. There are also reports on lung function impairment attributed to exposure to smoke from domestic cooking and hut fires.⁸ It has been observed that some persons chronically exposed to smoke and volatile compounds generated from fish drying using burning firewood have developed respiratory symptoms and eventually

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respiratory complications (EJP's personal observation). However, there is a scarcity of data on the ventilatory function status of persons chronically exposed to fish drying using burning firewood. Therefore, the major objective of this study was to determine the effect of chronic exposure to fish drying using burning firewood on lung function. Respiratory and other symptoms prevalent among persons engaged in fishing have also been noted.

Materials and Methods

Location.

Three hundred and seventy five Nigerians aged between 20 to 45 years who had been engaged in fish drying for a minimum of five years were recruited into the study. They were selected from three fishing settlements namely; Ibaka, Utaewa and Ikang. The fishing was done on rivers that join the Atlantic Ocean.

Test Subjects.

The subjects were chosen from the above mentioned fishing settlements with the number from each settlement relatively proportional to the size of the population in the fishing settlement. Thus, about 50% of the subjects were drawn from Ibaka fishing settlement while the remaining 50% came from Utaewa and Ikang fishing settlements respectively. The study received the approval of each fishing community and informed voluntary consent was obtained from each subject. All the subjects in the test group used a similar local method of fish drying. The method involved the use of large mud stands with firewood and charcoal which served as a source of fire and smoke. Drying wire nets were placed about one meter above the mud stand and the fish were placed on top of the nets. The fish drying was usually done in the open. However, during the rains, it was done in shelters with thatched roof and walls.

Control Population.

The control population consisted of 300 apparently healthy Nigerian males and females. They were sex matched with the test group. They were also drawn from the same area but were not exposed to any air pollutant. They were non cigarette smokers and had never smoked cigarettes. Since the lung function of ex-cigarette and current cigarette smokers was reported to be worse than in subjects that never smoked cigarettes,⁹ our control subjects were never cigarette smokers.

Procedure.

Subjects were called in groups and instructed on the test procedure. To facilitate the understanding of the test procedure, demonstration of the test was performed and any questions answered. The lung function was determined by the use of a mini-Wright peak flow meter (Air Med. Ltd, Harlow, England) and an S model Vitalograph spirometer (Vitalograph Ltd, Buckingham, England). The vitalograph spirometer was used to determine forced vital capacity (FVC), forced expiratory volume in one second (FEV₁), forced expiratory volume in one second as a percentage of the vital capacity (FEV₁%), while the peak flow meter was used to measure peak expiratory flow rate (PEFR). Three trials were made per subject using the vitalograph spirometer and the curves obtained for analysis met American Thoracic Society standards.¹⁰

The best recording was used to obtain a reading at body temperature and pressure saturated with water vapour. After

waiting for the respiratory rate to return to baseline, the subject was asked to take a deep breath and then blow out forcefully into a mini-Wright peak flow meter. Each subject was also allowed three trials at one minute intervals. The best of the three trials was also. All the tests were performed standing. The same procedure was repeated for the 300 control subjects.

Since sex is an important factor that affects ventilatory function,¹¹ the ventilatory function parameters and corresponding anthropometric parameters (age, height and body weight) of the test subjects were separated into male and female groups for comparisons with their controls.

Data Analysis.

Results were expressed as means and standard deviations (SD) as well as percentages. The student's 't' test was used to compare means. The chi squared test was used to compare proportions or percentages. The Pearson's product moment correlation coefficient (r) between variables was done to test for linear association between continuous variables. P values less than 0.05 were taken to indicate statistically significant results. Results were expressed as means and standard deviation (SD).

Results

Anthropometric and lung function parameters among fishermen and their controls.

Table I shows that the mean values of the anthropometric parameters (age, height and weight) of men engaged in fishing and their control group were not significantly different. In contrast, values of the lung function parameters namely, PEFR, FVC, FEV₁ and FEV₁% of the cases were all significantly lower than those of their controls (p<0.001). However, while none of the subjects in the control group was a current cigarette or ex-cigarette smoker, the cases who were current cigarette and ex-cigarette smokers comprised 12.2% and 27.3% of the group, respectively.

Table I: Comparison of anthropometric and ventilatory function parameters between men engaged in fishing (cases) and their control group.

Anthropometric and ventilatory function parameters	Case group Total=183 Mean (SD)	Control group Total=142 Mean (SD)	p value
Height (m)	1.60 (0.11)	1.62 (0.12)	>0.05
Weight (kg)	62.1 (4.5)	62.1 (5.2)	>0.05
Age (years)	35.2 (2.6)	35.8 (3.0)	>0.05
PEFR (L/min)	335 (22)	592 (99)	<0.001
FVC (L)	2.98 (0.20)	3.52 (0.29)	<0.001
FEV ₁ (L)	2.08 (0.18)	2.82 (0.25)	<0.001
FEV ₁ %	69.8 (3.1)	80.2 (6.7)	<0.001
Cigarette smokers — n (%)	22 (12.2)	0 (0)	<0.001
Ex-cigarette smokers — n (%)	50 (27.3)	0 (0)	<0.001

Anthropometric and lung function parameters in women engaged in fishing and their controls.

Table II shows that the mean values of the anthropometric parameters of women engaged in fishing and their control group were not significantly different. In contrast, the mean

values of the lung function parameters namely, PEFR, FVC, FEV₁, and FEV₁% of the cases were all significantly lower than their controls ($p < 0.001$). There were no current cigarette and ex-cigarette smokers among the control group, whereas the cases who were current cigarette and ex-cigarette smokers comprised 1.1% and 2.6% of the group, respectively.

Table II: Comparison of anthropometric and ventilatory function parameters between women engaged in fishing (cases) and their control group.

Anthropometric and ventilatory function parameters	Case group Total=183 Mean (SD)	Control group Total=142 Mean (SD)	p value
Height (m)	1.57 (0.10)	1.59 (0.11)	>0.05
Weight (kg)	55.1 (4.4)	56.2 (4.5)	>0.05
Age (years)	33.1 (2.3)	33.6 (2.6)	>0.05
PEFR (L/min)	298 (22)	418 (34)	<0.001
FVC (L)	2.42 (0.17)	3.02 (0.24)	<0.001
FEV ₁ (L)	1.70 (0.19)	2.55 (0.21)	<0.001
FEV ₁ %	72.9 (3.2)	84.4 (6.7)	<0.001
Cigarette smokers — n (%)	2 (1.1)	0 (0)	>0.05
Ex-cigarette smokers — n (%)	5 (2.6)	0 (0)	>0.05

Anthropometric and ventilatory function parameters of fishermen who were never cigarette smokers and their control subjects.

Table III compares the anthropometric and lung function parameters of men engaged in fishing who were never cigarette smokers and their controls who also had never smoked cigarettes. It shows that the anthropometric parameters of the two groups were not significantly different. However, the lung function parameters, PEFR, FVC, FEV₁ and FEV₁% were all significantly lower in the cases who were never cigarette smokers than in their control subjects ($p < 0.001$).

Table III: Comparison of anthropometric and ventilatory function parameters between men engaged in fishing (cases) who were never cigarette smokers and their never-cigarette smoking control subjects.

Anthropometric and ventilatory function parameters	Case group Total= 111 Mean (SD)	Control group Total=142 Mean (SD)	p value
Height (m)	1.63 (0.21)	1.62 (0.12)	>0.05
Weight (kg)	63.6 (4.8)	62.8 (5.2)	>0.05
Age (years)	35.3 (2.9)	35.8 (3.0)	>0.05
PEFR (L/min)	336 (20)	592 (99)	<0.001
FVC (L)	2.95 (0.21)	3.52 (0.29)	<0.001
FEV ₁ (L)	2.06 (0.19)	2.82 (0.25)	<0.001
FEV ₁ %	69.8 (3.0)	80.2 (6.7)	<0.001

Anthropometric and ventilatory function parameters of women engaged in fishing who were never cigarette smokers and their control subjects.

Table IV compares the anthropometric and lung function parameters of women engaged in fishing who were never cigarette smokers and their controls who also had never smoked cigarettes. It shows that the anthropometric parameters of the two groups were not significantly different. However, the lung function parameters, PEFR, FVC, FEV₁ and FEV₁%

were all significantly lower in women engaged in fishing who were never cigarette smokers than in their control subjects ($p < 0.001$).

Table IV: Comparison of anthropometric and ventilatory function parameters between women engaged in fishing (cases) who were never cigarette smokers and their never-cigarette smoking control subjects.

Anthropometric and ventilatory function parameters	Case group Total=185 Mean (SD)	Control group Total=158 Mean (SD)	p value
Height (m)	1.58 (0.22)	1.59 (0.11)	>0.05
Weight (kg)	55.4 (3.5)	56.2 (4.5)	>0.05
Age (years)	33.8 (2.4)	33.6 (2.6)	>0.05
PEFR (L/min)	301 (20)	418 (34)	<0.001
FVC (L)	2.47 (0.20)	3.02 (0.24)	<0.001
FEV ₁ (L)	1.78 (0.17)	2.55 (0.21)	<0.001
FEV ₁ %	72.1 (3.4)	84.4 (6.7)	<0.001

Age and sex distribution of men and women engaged in fishing.

Table V shows the age and sex distribution of the men and women engaged in fishing. All the persons engaged in fishing were in the age group 20 to 45 years of age. A total of 114 (30.4%) of them were in the 40 to 45 age group. The distribution of the males and females in all the age groups was similar ($\chi^2=5.87$; $df=4$; $p=0.209$).

Table V: Age and sex distribution of men and women engaged in fishing.

Age group (years)	Total cases Total= 375 n (%)	Men Total= 183 n (%)	Women Total=192 n (%)
20-24	51 (13.6)	24 (13.1)	27 (14.1)
25-29	72 (19.2)	30 (16.4)	42 (21.9)
30-34	78 (20.8)	36 (19.7)	42 (21.9)
35-39	60 (16.0)	27 (14.8)	33 (17.2)
40+	114 (30.4)	66 (36.1)	48 (25.0)

Duration of service of the men and women in the fish drying business.

Table VI shows the distribution of both men and women according to their duration of service in the fish drying occupation. Most (54.4%) of the respondents in the fish drying business had five to nine years duration of service, while only 11.2% of them had spent more than 20 years in the business. The duration of service of both males and females was similar ($\chi^2=2.27$; $df=4$; $p=0.686$).

Table VI: Duration of service of men and women in the fish drying business.

Duration of service (years)	Total cases Total=375 n (%)	Men Total=183 n (%)	Women Total=192 n (%)
5-9	204 (54.4)	108 (59.0)	96 (50.0)
10-14	99 (26.4)	48 (26.2)	51 (26.6)
15-19	30 (8.0)	15 (8.2)	15 (7.8)
20-24	24 (6.4)	9 (4.9)	15 (7.8)
25+	18 (4.8)	9 (4.9)	9 (4.7)

Relationship between lung function parameters and duration of exposure of the men and women engaged in fishing.

Table VII shows a correlation of lung function parameters PEFR, FVC, FEV₁ and FEV₁% with the duration of service of the men and women engaged in fishing. The negative coefficient of correlation (r) indicates a general decline of lung function values with an increase in the duration of exposure of the men and women to fish drying. The relationship was significant for duration of service versus PEFR, FVC and FEV₁ (P<0.001).

There was no significant relationship between lung function parameters and age, as well as smoking habit of the men and women engaged in fishing (p>0.05).

Table VII: Correlation between lung function parameters and duration of exposure of the men and women in fish drying.

Parameter	PEFR		FVC		FEV ₁		FEV ₁ %	
	r	p value	r	p value	r	p value	r	p value
Duration of exposure Males: n=183	-0.97	<0.001	-0.95	<0.001	-0.96	<0.001	0.19	>0.05
Duration of exposure Females: n=192	-0.98	<0.001	-0.96	<0.001	-0.94	<0.001	0.14	>0.05

Prevalence of respiratory symptoms.

Data in Tables VIIIA and VIIIB are combined for both sexes because there were no sex differences in prevalences of respiratory symptoms. There were significantly higher prevalences of respiratory symptoms among the men and women in the fishing industry than in their controls (Table VIIIA). Mild to moderate cough with sputum topped the list of respiratory symptoms with 50.4% of the cases suffering from the disorder. This was followed by chest pain, dyspnoea, catarrh and sneezing, unproductive cough, wheezing and severe productive cough. In contrast, only 1.7% and 3.3% of the control had mild to moderate cough with sputum and unproductive cough, respectively. No other respiratory symptoms were observed among the control subjects.

Table VIIIA: Comparison of respiratory symptoms observed among men and women in fishing industry and their controls.

Respiratory symptoms	Cases Total=375 n (%)	Controls Total=300 n (%)	p value
Unproductive cough	48 (12.8)	10 (3.3)	<0.001
Mild to moderate cough + sputum	189 (50.4)	5 (1.7)	<0.001
Severe productive cough	18 (4.8)	0 (0)	<0.001
Dyspnoea	66 (17.6)	0 (0)	<0.001
Wheezing	36 (9.6)	0 (0)	<0.001
Chest pain	90 (24.0)	0 (0)	<0.001
Catarrh and sneezing	66 (17.6)	0 (0)	<0.001

Other non-respiratory symptoms observed also had higher prevalences in the fishing group than in the control group (Table VIIIB). Eye irritation topped the list with 41.6% followed by skin irritation, internal heat and headache. In contrast, only 1.0%, 1.3% and 1.0% of the control group had skin irritation, headache and internal heat respectively. There was no incidence of eye irritation among the controls.

Table VIIIB: Comparison of other symptoms observed among cases and controls.

Symptoms	Cases Total=375 n (%)	Controls Total=300 n (%)	p value
Skin irritation	108 (28.8)	3 (1.0)	<0.001
Eye irritation	159 (42.4)	0 (0)	<0.001
Headache	48 (12.8)	4 (1.3)	<0.001
Internal heat	72 (19.2)	3 (1.0)	<0.001

Discussion

This study has shown significant ventilatory function impairment among persons engaged in fishing chronically exposed to fish drying using burning firewood. The mean values of ventilatory function (FVC, FEV₁, FEV₁% and PEFR) of the control group, were similar to values obtained by other workers for normal adult Nigerians.^{12,13} All the ventilatory function indices of the persons exposed to fish drying were significantly lower than their control values. On the other hand, the anthropometric parameters, namely: age, height and body weight that affect ventilatory function¹¹ were not statistically different between the fishing group and the control group.

Since cigarette smoking impairs lung function,^{4,6} and a few persons engaged in fishing were ex and current cigarette smokers while there was no ex and current smoker among the controls, it might be argued that the lower ventilatory function values among the fishing subjects could be attributed to their smoking habit. However, the comparison of cases who were not ex or current smokers, that is, who had never smoked cigarettes, with their controls showed that the ventilatory function indices of the cases who had never smoked were also significantly lower than the control group. This rules out the possibility that the impairment of lung function among the cases was due to their smoking status. The reduced ventilatory function indices in the cases may, therefore, be attributed to occupational exposure. The impairment (reduced FVC, FEV₁, FEV₁% and PEFR) is indicative of a mixed pattern (both obstructive and restrictive) of ventilatory defect.¹⁴

Reduced ventilatory function indices have also been reported by other investigators who studied persons exposed to smoke from fire fighting, unventilated coal, kerosene or fire wood stoves.^{7,15} Sandoval *et al*¹⁶ also reported that chronic inhalation of domestic wood smoke is associated with reduced lung function and may ultimately result in wood smoke inhalation associated lung disease (WSIALD).

The rivers where the fish were caught flow into the Atlantic Ocean and so, both fresh water fish and fresh salt water fish were available for the drying process. The fresh water fish

available in the area include mud fish, cat fish and trouts. Fresh salt water fish available were mackerel and sardine. Several volatile components have been detected from these two groups of fish.

Nitrogen containing compounds such as ammonia, trimethylamine (TMA) and dimethylamine (DMA), acetic, formic, propanoic acids and sulfur containing compounds and methanethiol are volatile compounds often detected from fresh salt water fishes, while piperidine and ethanal are the volatile compounds from freshwater fish and are responsible for the characteristic earthy odours of the fish.¹⁷ During heating, as it is the case in fish drying using burning firewood, the production of the volatile components increases.¹⁷ Although the effects of many of the volatile components of fish on lung function have not been reported, the inhalation of ammonia has been reported to damage the respiratory system and impair lung function.¹⁸ Our study did not however, ascertain whether the impairment of lung function in the fishing group was due to the inhalation of wood smoke or volatile components from the fish during drying. For technical reason, it was not possible to separate the two factors.

There was an increased prevalence of respiratory and other symptoms among persons engaged in fishing when compared to their controls. The most prevalent respiratory symptom was mild to moderate cough with sputum. Cough is in consonance with the mixed ventilatory defect observed in persons engaged in fishing.¹⁹ The most prevalent non-respiratory symptoms were eye and skin irritation. These may have been caused by irritant and volatile components of the fish emitted during the drying process or smoke from burning firewood. The high prevalence of non-respiratory symptoms observed in this study has also been reported by other investigators who studied people in similar work environments such as those exposed to fire fighting and domestic wood smoke inhalation.^{7,16}

The severity of all the symptoms in persons engaged in fishing correlated with prolonged duration of exposure at work environment. The worsening of lung function in relation to the length of service may be a reflection of the severity of the observed symptoms with time. Deterioration of lung function with increased length of exposure to various pollutants, including smoke, has also been reported by various investigators.^{7,8,21-23} It was however, interesting to note that in spite of the significant decrease in lung function and high prevalence of respiratory and other symptoms, many of the persons in the fishing industry were quite active in the fish drying business. However, the worsening of lung function with time of exposure suggests the importance of length of exposure in the etiology of lung function impairment. So, with time the efficiency of the persons engaged in the fish drying business will be compromised and their morbidity and mortality will increase.

In conclusion, chronic exposure to fish drying using burning firewood may impair lung function and cause respiratory and other symptoms. There is, therefore, the need to look for other safer methods of fish preservation.

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