Indoor air pollution and respiratory symptoms among fishermen in the Niger delta of Nigeria

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Abstract

Biomass is heavily depended on for domestic energy use by people in developing countries. Combustion of these materials produces a lot of smoke. Exposure to this indoor air pollution has been linked to a number of respiratory disorders. The aim of our study was an assessment of the long-term respiratory effects of indoor air pollution.

A survey was conducted in the riverine areas of the Niger Delta of Nigeria among 521 fishermen exposed to indoor air pollution from burning firewood and 545 matched controls. Exposure was determined by the product of the average daily duration of time spent close to the fire and the number of years (hours–years). A modified British Medical Research Council (BMRC) questionnaire was used to obtain information on respiratory symptoms and spirometry was performed on the participants.

The frequency of chronic respiratory symptoms was significantly higher among the exposed fishermen compared with the control subjects. Chronic bronchitis was significantly associated with an obstructive ventilatory pattern. Logistic regression analysis showed an increased risk for chronic bronchitis among exposed fishermen (OR 8.7; 95% CI 4.7–16.3, p<0.001); women were six times more likely than men to develop chronic bronchitis (OR 6.6; 95% CI 2.5-17.8, p< 0.001); and cigarette smokers were five times more likely than non-smokers to develop chronic bronchitis (OR 5.0; 95% CI 1.8–13.8, p<0.05).

The results of this survey showed an association between exposure to indoor air pollution and chronic respiratory disorders. Cigarette smoking aggravated this association.

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Introduction

Approximately 50% of the world population, and up to 90% of the population in developing countries rely on burning biomass fuels for everyday household energy needs.[1] Often, the stoves have poor combustion capacity and can utilise only a fraction of available fuel energy.[2] These stoves produce heavy smoke and release a number of harmful pollutants.[3]

The use of biomass for cooking and heating usually takes place in poorly ventilated homes.[4] The fires are kept going for many hours a day thus exposing the occupants to years of daily smoke.[5] Several studies have documented pollution levels in such homes,[6,7] and these levels may be up to 200 times higher than recommended levels.[8,9] The health effect of indoor air pollution is determined not just by the pollution level but also by the time people spend breathing polluted air.[10,11] Thus exposure to indoor air pollution from the combustion of biomass fuels constitutes a significant public health hazard affecting predominantly poor communities in developing countries.[12,13]

Exposure to indoor air pollution has been linked to a number of respiratory illnesses, including acute respiratory infection,[14,15] chronic bronchitis,[16,17] asthma,[18] chronic obstructive pulmonary disease (COPD),[19–21] tuberculosis,[22,23] and possibly lung cancer.[24,25]

In Nigeria, World Health Organization (WHO) estimates put biomass fuel use at 67% for the year 2002 and the total deaths attributed to indoor air pollution from biomass smoke at 79 000.[26]

Few studies have examined the acute effects of exposure to indoor air pollution and fewer still the long-term consequences. Previous studies by Peters et al[27,28] and Akani et al[29] have shown that exposure to indoor air pollution from biomass smoke is associated with an increase in the frequency of acute respiratory symptoms. This study was, therefore, undertaken to examine the relationship between long-term exposure to indoor air pollution from firewood smoke and chronic respiratory disorders among fishermen.

Materials and methods

Study area

Two riverine communities, Ibaka and Ikang, were selected for this study. Ibaka is a coastal fishing settlement in Mbo local government area in Akwa Ibom State, Nigeria. It had an estimated population of 176 680people in the 2006 national population census. It is located south-west of Calabar on the coastal plain and it is accessable by sea and road. Ikang is in Akpabuyo local government area of Cross River State, Nigeria. This is a similar settlement to Ibaka but it is smaller with an estimated population in the national population census of 2006 of 13 582 people.[30] The main industry in these areas is fishing.

Subjects

Fishermen who are exposed to indoor air pollution from firewood smoke while drying fish were selected for this survey. The fish drying process is usually carried out indoors in drying huts. These huts are constructed with dried mud bricks with a thatch roof. An average drying hut will measure 7 by 4 metres with a door at each end of the room, but no windows. The drying area is constructed by placing a wire mesh or sticks on wooden supports at a height of about 1.3 metres above the ground. Firewood is burnt beneath the net to produce heat and smoke while the fish is placed on the net over the fire.

There were over 2500 houses spread out in 8 clusters. Each cluster contained about 300 houses. One hundred (100) subjects were selected from each cluster of houses. A subject was selected from every third house by simple ballot and the first house was selected by the same process.

Six hundred and two (602) fishermen were invited to participate in this survey. They were interviewed and examined and and their anthropometric and ventilatory parameters measured. Eighty-one (81) fishermen opted out of the survey, or could not produce good spirograms, leaving 521 test subjects. The control subjects were fishermen drawn from the same fishing settlements.

Interview

A modified British Medical Council respiratory disease questionnaire (BMRC)[31] was translated into the local language and then translated back into English to ensure consistency. The local language version was used for the majority of the subjects who could not understand English. The English language version was used on a few subjects that could communicate well in English. The questionnaire was used to document demographic data and to obtain relevant clinical information. Chronic bronchitis was defined as productive cough on most days for 3 months in 2 consecutive years. Other respiratory symptoms sought for were wheezing and shortness of breath. A history of cigarette smoking was documented for each participant.

Lung volume measurements

A Vitalograph spirometer model R was used to measure the forced expiratory volume in one second (FEV1) and the forced vital capacity (FVC). The volume accuracy of the spirometer was checked regularly after every 10th subject with a single discharge of a 2-litre calibration syringe. The accuracy of the mechanical recorder time-scale was checked regularly by comparing the speed against a stop watch after every 10th subject. At least three trials per subject were taken with at least three curves that meet the American Thoracic Society (ATS) criteria.[32] Cumulative exposure to biomass smoke among the test subjects was given as the product of hours spent near the fire and the years spent drying fish (hour–years) as used in a previous study.[17]

Statistical analysis

Results obtained from both test and control subjects were analysed using the Statistical Package for Social Sciences (SPSS) 16.0 computer software. Qualitative data were given as frequency distribution and cross-tabulation while quantitative data were given as mean and standard deviation. Independent t test was used to compare means between unpaired samples while chi square test was used to test for strength of association between categorical variables. A p-value of less than 0.05 was considered to be statistically significant.

Results

Five hundred and twenty-one (521) fishermen exposed to indoor air pollution and 545 control subjects were recruited into the study (see Table 1). The subjects were well matched in terms of age, sex, educational status, and cigarette smoking habits ($p>0.05$).

The frequencies of respiratory symptoms among the male and female subjects were compared (see Tables 2 and 3). All those who were exposed to firewood smoke reported significantly more episodes of chronic phlegm production, difficulty in breathing, wheeze, and chronic bronchitis ($p<0.001$).

The frequency of respiratory symptoms among smokers was compared (see Table 4). The cigarette smokers who

Parameter	Control n (%)	Test n (%)	Total n (%)	χ^2	p
Age					
20–30	60 (11)	56 (10.7)	116 (10.9)		
31–40	154 (28.3)	150 (28.8)	304 28.4)		
41–50	171 (31.4)	167 (32.1)	338 (31.6)		
51–60	160 (29.4)	148 (28.4)	308 (31.6)	0.165	>0.05
Gender					
Female	350 (64.2)	342 (65.6)	692 (64.9)		
Male	195 (35.8)	179 (34.4)	374 (35.1)	0.373	>0.05
Education					
None	25 (4.6)	27 (5.1)	52 (4.8)		
Primary	399 (73.2)	398 (76.4)	797 (74.4)		
Secondary	121 (22.2)	96 (18.4)	214 (20.3)	2.419	>0.05
Cigarette smoking					
No	456 (83.7)	432 (83.6)	888 (83.3)		
Yes	89 (16.3)	89 (16.4)	174 (16.7)	0.11	>0.05

Table 1 General characteristics of control and test groups

Symptom	Present n (%)	Total	χ^2	p
Phlegm				
Control	93 (39.1)	350		
Test	145 (42.4)	342	19.2	<0.001
Dyspnoea				
Control	5 (1.4)	350		
Test	23 (6.7)	342	12.5	<0.001
Wheeze				
Control	5 (1.4)	350		
Test	72 (21.1)	342	67.4	<0.001
Chronic bronchitis				
Control	10 (2.9)	350		
Test	58 (17.0)	342	38.8	<0.001

Table 2 Frequency of respiratory symptoms among 342 female subjects

Symptom	Present n (%)	Total	χ^2	p
Phlegm				
Control	13 (6.7)	195		
Test	39 (21.8)	179	17.8	<0.001
Dyspnoea				
Control	0 (0.0)	195		
Test	19 (10.6)	179	21.8	<0.001
Wheeze				
Control	1 (0.5)	195		
Test	32 (17.9)	179	35.0	<0.001
Chronic bronchitis				
Control	2 (1.0)	195		
Test	26 (14.5)	179	24.5	<0.001

Table 3 Frequency of respiratory symptoms among male subjects

Symptom	Present n (%)	Total	χ^2	p
Phlegm				
Control	6 (6.7)	89		
Test	23 (25.8)	89	11.9	<0.001
Dyspnoea				
Control	0 (0.0)	89		
Test	15 (16.9)	89	16.4	<0.001
Wheeze				
Control	1 (1.1)	89		
Test	28 (31.5)	89	30.0	<0.001
Chronic bronchitis				
Control	2 (2.2)	89		
Test	21 (23.6)	89	18.0	<0.001

Table 4 Frequency of respiratory symptoms among all smokers

were exposed to firewood smoke reported significantly more episodes of chronic phlegm production, difficulty in breathing, wheeze and chronic bronchitis than the control cigarette smokers (p<0.001).

The relationship between chronic bronchitis and age among the subjects was examined (see Figure 1) there was an upward trend in the prevalence of chronic bronchitis among the exposed fishermen while the control subjects showed an almost equal prevalence within the age groups except for those within the 20–30 years age bracket which displayed a spike in prevalence.

The relationship between the average FEV1/FVC ratio and age was evaluated among the subjects (see Figure 2). There was a slight decline in FEV1/FVC ratio of the control subjects with age while the exposed fishermen showed a steep decline in the FEV1/FVC ratio with increase in age.

The relationship between ventilatory pattern and the presence of chronic bronchitis among test subjects was

Ventilatory defect	Present n (%)	Total	χ^2	p
Obstruction				
No chronic bronchitis	154 (35.2)	437		
Chronic bronchitis	79 (94)	84	98.56	<0.001
Restriction				
No chronic bronchitis	18 (4.1)	437		
Chronic bronchitis	8 (9.5)	84	4.34	0.52
Combined obstruction and restriction				
No chronic bronchitis	5 (1.1)	437		
Chronic bronchitis	8 (9.5)	84	20.33	<0.001

Table 5 Frequency of ventilatory defects among test subjects with and without chronic bronchitis

Factor	B	Sig.	OR	95% CI for OR
Age	0.063	<0.001	1.065	1.036–1.095
Sex	-1.886	<0.001	6.57	2.45–17.82
Education	-0.429	0.097	1.53	0.92–2.55
Exposure	2.163	<0.001	8.69	4.65–16.27
Cigarette smoking	1.601	0.002	4.96	1.77–13.82

Notes
R^2=10.1–22.3%
Overall significance of equation p<0.001
Equation prediction = 91% of cases

Table 6 Logistic regression for factors that predict the presence of chronic bronchitis

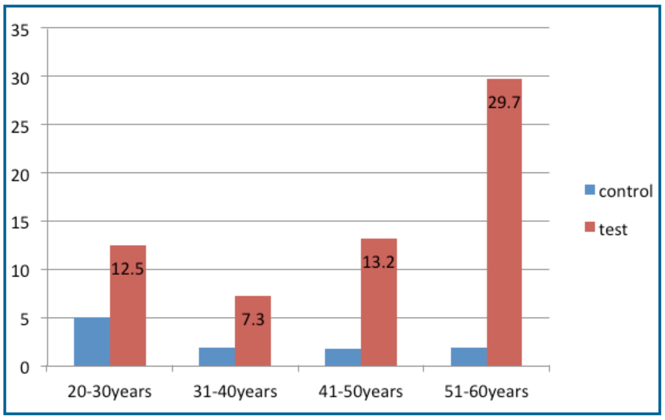

Figure 1 Distribution of chronic bronchitis among subjects

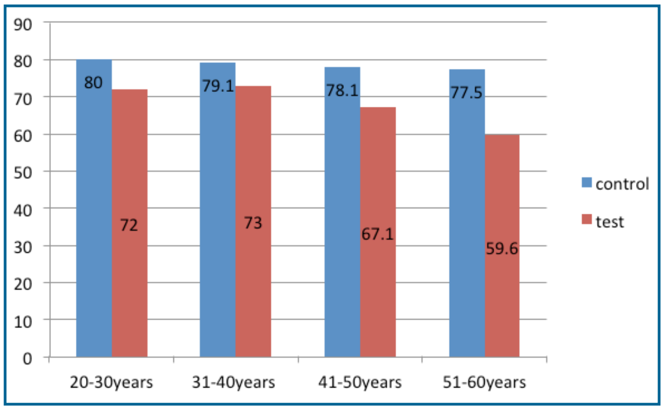

Figure 2 Average FEV1/FVC per cent distribution among the test and control subjects

examined (see Table 5); 79 (94.0%) subjects with chronic bronchitis had an obstructive ventilatory pattern compared with 154 (35.2%) of the exposed fishermen without chronic bronchitis ($p<0.001$), with a 29-fold increased risk of developing airflow limitation. There was no significant association between chronic bronchitis and restrictive ventilatory defect ($p>0.05$). The combination of airflow limitation and restriction was significantly associated with chronic bronchitis ($p<0.05$).

Direct logistic regression was performed to assess the impact of a number of variables on the likelihood that a subject would be diagnosed with chronic bronchitis (see Table 6). The model contained the variables age, gender, educational attainment, exposure to firewood smoke, and cigarette smoking. The full model containing all predictor variables was statistically significant $\chi^2=113.9$, $p<0.001$ indicating that the model was able to predict subject with chronic bronchitis and subjects without it. The model as a whole explained between 10 and 22 % of the variance of chronic bronchitis and correctly classified 91% of the cases. Educational attainment did not make a unique significant contribution to the model with exposure to firewood smoke being the strongest predictor for the development of chronic bronchitis with an odds ratio of 8.69, indicating that subjects with exposure to indoor air pollution from firewood smoke were eight times more likely to be diagnosed with chronic bronchitis than those without any such exposure, controlling for other variables in the model. The females were six times more likely to be diagnosed with chronic bronchitis while cigarette smokers were four times more likely to be diagnosed with chronic bronchitis.

Discussion

This study set out to investigate the relationship between exposure to firewood smoke and chronic respiratory disorders among fishermen. The symptoms were significantly more prevalent among the exposed fishermen than the unexposed controls and this increased with the level of exposure. This is in agreement with observations by Peters et al[28] when they studied lung function and respiratory symptoms in rural subjects exposed to biomass smoke more than a decade earlier. In that study, mild-to-moderate cough was the most common symptom (50.4%), followed by dyspnoea (17.6%) and wheeze (9.6%). Desalu et al[33] in a previous study of respiratory symptoms among women using biomass fuels for domestic cooking in rural south-western Nigeria, found that the women who used biomass fuels, when compared with those who used a non-biomass fuel, more often reported symptoms of cough (13.7% vs. 3.7%), wheezing (8.7% vs. 2.8%), breathlessness (11.8% vs. 6.5%), and chronic bronchitis (10.6% vs. 2.8%).

Cigarette smoking increased the frequency of respiratory symptoms for both the test and control subjects. But the frequency of respiratory symptoms was still significantly higher among the exposed fishermen who smoked cigarettes compared with the control subjects who also smoked cigarettes. The association of cigarette smoking and indoor air pollution from biomass smoke was examined by Pandey in a previous study of indoor air pollution and chronic bronchitis in rural Nepal and he found that smokers had a higher prevalence of chronic bronchitis.[16]

Among the exposed fishermen, chronic bronchitis exhibited a significant association with obstructive ventilatory defects and combined obstructive and restrictive ventilatory defects and none at all with restrictive ventilatory defects. Perez-Padilla et al,[20] in a previous study of chronic bronchitis in Mexican women, found a significant association between chronic bronchitis, chronic airway obstruction, and wood smoke exposure. They found that the risk of chronic bronchitis alone and chronic bronchitis with chronic airway obstruction increased linearly with the exposure (hour-years) of cooking with a wood stove; odds ratios for exposure to more than 200 hour-years compared with non-exposure were 15.0 (95% CI, 5.6–40) for chronic bronchitis only and 75 (95% CI, 18–306) for chronic bronchitis with chronic airway obstruction. Their findings suggest a causal role of exposure to indoor air pollution in chronic bronchitis and chronic airflow obstruction. Similar findings were also reported by Norboo et al[34] in a study of domestic air pollution and respiratory symptoms in a Himalayan village. They found that FEV1/FVC ratio was, independently of age and sex, significantly lower in the subjects reporting chronic cough relative to those with no cough ($p<0.01$).

In this study, long-term exposure to indoor air pollution was the biggest risk factor associated with the development of chronic bronchitis. This has been corroborated by previous studies.[31–33] A history of cigarette smoking was also significantly associated with chronic bronchitis. None of the women were cigarette smokers but a female was six times more likely to report chronic bronchitis than a male; this may be due to greater exposure of the females to indoor air pollution when they perform domestic cooking with biomass fuels which the men generally do not do.

Educational attainment did not make a significant individual contribution to the prediction of chronic bronchitis. This was an unexpected finding as one would have thought that a higher educational level should confer some protection against smoke exposure (individuals should have been more aware of the health risk of exposure to indoor air pollution). This may be due to the fact that majority of the subjects (79.5%) had less than 6 years of formal education and, being a rural setting, the quality of education may not be optimal.

Although the overall prevalence of chronic bronchitis increased with age it did not do so consistently between the exposed and the control groups, with the exposed fishermen showing a consistent rise in prevalence while the control group did not show any such rise. The rise in prevalence of chronic bronchitis among the exposed fishermen may be due to the increased exposure associated with increasing age.

Conclusion

This study has shown that the symptoms of respiratory disease and chronic bronchitis are more prevalent among fishermen exposed to indoor air pollution from biomass smoke and this pattern has not changed over the years. As a result, there is a need to introduce appropriate safety measures and interventions to prevent and reduce the impact of long-term complications of biomass smoke exposure. The fishermen should be introduced to the use of more efficient means of burning firewood and also improve the ventilation of their buildings by constructing windows and chimneys to vent the smoke to the exterior.

Further studies will be required to study the impact of these interventions on the health of the fishermen.

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