Increased risk of respiratory symptoms and chronic bronchitis in women using biomass fuels in Nigeria*, **

Risco aumentado de sintomas respiratórios e bronquite crônica em mulheres que utilizam biocombustíveis na Nigéria

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Abstract

Objective: To determine whether respiratory symptoms and chronic bronchitis are associated with the use of biomass fuels (BMFs) among women residing in rural areas of the Ekiti State, in southwestern Nigeria. **Methods:** From January to June of 2009, we carried out a cross-sectional study including 269 adult women. To collect data on sociodemographic status, type of fuel used for cooking in the household, respiratory symptoms, and smoking history, we used a questionnaire adapted from the European Community Respiratory Health Survey. All of the participants were invited to undergo spirometry. **Results:** Of the 269 women in the study, 161 (59.9%) used BMFs for cooking. The proportion of women who reported respiratory symptoms was greater among those using BMFs than among those using a non-BMF—cough (13.7% vs. 3.7%); wheezing (8.7% vs. 2.8%); chest pain (7.5% vs. 1.9%); breathlessness (11.8% vs. 6.5%); nasal symptoms (9.3% vs. 4.6%); and chronic bronchitis (10.6% vs. 2.8%). Multivariate logistic regression analysis revealed that the use of BMFs was associated with the following variables: cough (OR = 4.82; p = 0.01); chronic bronchitis (OR = 3.75; p = 0.04); wheezing (OR = 2.22; p = 0.23); chest pain (OR = 3.82; p = 0.09); breathlessness (OR = 1.54; p = 0.35); and nasal symptoms (OR = 2.32; p = 0.20). All of the spirometric parameters evaluated (FEV_1, FVC, FEV_1/FVC ratio, and PEF) were lower in the women using BMFs than in those using a non-BMF. **Conclusions:** Our results underscore the need for women using BMFs in their households to replace them with a nontoxic type of fuel, such as electricity or gas.

Keywords: Signs and symptoms, respiratory; Biofuels; Bronchitis, chronic; Air pollution, indoor.

Resumo

Objetivo: Determinar a associação de sintomas respiratórios e bronquite crônica com o uso de biocombustíveis entre mulheres habitantes de áreas rurais do estado de Ekiti, sudoeste da Nigéria. **Métodos:** De janeiro a junho de 2009, realizou-se um estudo transversal com uma amostra de 269 mulheres adultas. Um questionário adaptado do *European Community Respiratory Health Survey* foi aplicado para a obtenção de dados sobre características sociodemográficas, tipo de combustível utilizado para a preparação de alimentos, sintomas respiratórios e história de tabagismo. Todas as participantes foram convidadas a realizar espirometria. **Resultados:** Das 269 mulheres no estudo, 161 (59,9%) utilizavam biocombustíveis para a preparação de alimentos. As mulheres que utilizavam biocombustíveis relataram mais sintomas respiratórios que aquelas que não os utilizavam — tosse (13,7% vs. 3,7%); sibilância (8,7% vs. 2,8%); dor no peito (7,5% vs. 1,9%); falta de ar (11,8% vs. 6,5%); sintomas nasais (9,3% vs. 4,6%); e bronquite crônica (10,6% vs. 2,8%). A análise multivariada por regressão logística confirmou que o uso de biocombustíveis está associado às seguintes variáveis: tosse (OR = 4,82; p = 0,01); bronquite crônica (OR = 3,75; p = 0,04); sibilância (OR = 2,22; p = 0,23); dor no peito (OR = 3,82; p = 0,09); falta de ar (OR = 1,54; p = 0,35); e sintomas nasais (OR = 2,32; p = 0,20). Todos os parâmetros espirométricos avaliados (VEF_1, CVF, VEF_1/CVF e PFE) foram menores nas mulheres que utilizavam biocombustíveis do que naquelas que não os utilizavam. **Conclusões:** Nossos resultados enfatizam a necessidade de se substituir o uso de biocombustíveis nos domicílios pelo de um tipo de combustível atóxico, como eletricidade ou gás.

Descritores: Sinais e sintomas respiratórios; Biocombustíveis; Bronquite crônica; Poluição do ar em ambientes fechados.

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* Study carried out at the Federal Medical Centre, Ido-Ekiti, Nigeria.

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Introduction

Cooking in a household involves the use of solid and nonsolid fuels. Approximately 50% of the world population uses biomass fuels (BMFs) as the primary source of domestic energy for cooking.[1] Solid fuels consist of coal, which is a fossil fuel, and BMFs (wood, charcoal, dung, and crop residues), which can be produced from any rapidly renewable source of carbon, including plants, whereas nonsolid fuels consist of kerosene, liquefied petroleum gas, natural gas, and electricity, all of which are non-BMFs.[1,2] The use of BMFs has been associated with indoor pollution and unsafe levels of toxic emission.[1-3] In the smoke generated by the combustion of solid fuels (coal and BMFs), more than 200 chemicals and chemical compounds have been identified, 90% of which are inhalable particle matter with an aerodynamic diameter < 10 μm (PM_{10}).[2,3] Most of these—including PM_{10}, CO, nitrogen oxide, sulfur oxide, aldehydes (e.g., formaldehyde), polycyclic aromatic hydrocarbons (e.g., benzopyrene), volatile organic compounds, chlorinated dioxins, and free radicals—are irritants to the respiratory system.[4-6] Most of these lethal agents have been associated with infectious diseases, allergic airway diseases, and malignancy.[7] Indoor air pollution is the tenth leading preventable risk factor contributing to the global burden of disease and is ranked fourth in developing countries.[8] In Nigeria, significant proportions of the Nigerian population live below the poverty line and are unable to afford non-BMFs, which are cleaner and nontoxic. Most households in developing countries still resort to the use of BMFs, such as wood, charcoal, dung, and crop residues, for cooking.[1] Various studies have implicated BMF smoke as one of the causes of chronic bronchitis and obstructive airway diseases.[9-11] Studies on the use of domestic fuels and respiratory morbidity are scarce in West Africa. The objective of this study was to determine whether respiratory symptoms and chronic bronchitis are associated with the use of BMFs in rural women residing in Ekiti State, in southwestern Nigeria.

Methods

This was a cross-sectional study involving adult women in the Ijero local government area, in Ekiti State, between January and June of 2009. Of all countries in which the population is predominantly black, Nigeria is the most populous, with a population of 145 million, composed of more than 250 ethnic groups. Half of the population (53%) lives in the rural area. The women living in the study area are mostly traders and floor mat weavers.

The subjects were selected using a multistage stratified sample design. The localities that constituted the Ijero local government area were listed and classified as semi-urban or rural area settings. A sample frame of the rural area settings was drawn, and we randomly selected four settlements (Ijurin, Iloro, Odo-Owa, and Ipoti-Ekiti). A list of the streets within each selected settlement was drawn up, and a random selection of the streets was then made. From each selected street, adults who were ≥ 35 years of age and met the inclusion criteria were recruited to the study. Inclusion criteria were as follows: having resided in the study area for at least one year; and having never smoked. Women who were regularly using a combination BMFs and non-BMFs were excluded. All participants gave written (or thumb-printed) informed consent.

The survey instrument contained questions taken from the European Community Respiratory Health Survey (ECRHS) and from previous studies on chronic bronchitis.[9-11] The questionnaire was adapted to the local language using the standard procedure of forward- and back-translation, carried out by a professional translator. The study team revised the back-translation, and the translator checked this version against the original version of the ECRHS to ensure that semantic equivalence between items had been achieved. The instrument was then piloted among the study population to ensure understandability, clarity of wording, and reliability. The internal consistency of the adapted survey instrument was adequate (Cronbach's alpha coefficient = 0.84). Although this version has not been validated for use in Nigeria, the ECRHS is an internationally recognized questionnaire, validated in epidemiological studies in the European community. The questionnaires were administered by trained interviewers who were community health officers working in the area; they were given a one-day training session on how to administer the questionnaire and were required to demonstrate their proficiency through

role play. The interobserver variability (kappa statistic) was 0.8. The questionnaire was used in order to obtain data related to sociodemographic status, the type of fuel used for cooking in the household, history of passive smoking, respiratory symptoms in the last 12 months, and chronic bronchitis. We adopted the clinical definition of chronic bronchitis that has been found to be useful in epidemiological studies, although this clinical definition might not reflect the impact of airflow limitation on the morbidity and mortality in COPD patients.[12] Cough and sputum production can precede airflow limitation and vice-versa. According to the Global Initiative for Chronic Obstructive Lung Disease guidelines, chronic bronchitis is defined as cough and sputum production for at least 3 months and in each of 2 consecutive years.[12] Subjects were classified as BMF users if they had used BMFs for at least 6 months. After the questionnaire had been administered, each subject was scheduled to undergo spirometry at the Ipoti Community Health Centre, in the settlement of Ipoti-Ekiti. Spirometry was performed using a spirometer with a pressure transducer (Gold Standard; Micro Medical Ltd., Rochester, Kent, UK), in accordance with the American Thoracic Society and European Respiratory Society Joint Task Force Guidelines on pulmonary function testing.[13] We made an adjustment of 12% in the spirometric measurements, as required for an African population, and the highest values of FEV_1, FVC, FEV_1/FVC, and PEF, obtained with a difference of less than 0.2 L, were accepted as the representative values for each subject. The data were analyzed using the Statistical Package for the Social Sciences, version 15 (SPSS Inc., Chicago, IL, USA). We performed descriptive and frequency analysis of the general characteristics and of the prevalence of respiratory symptoms in the study population. Information on the type of cooking fuel was used to categorize the women into two groups: women using BMFs (firewood, straw, dung, or crop residues) and women using a non-BMF (gas, kerosene, or electricity). To determine the risk of respiratory symptoms and chronic bronchitis in relation to the type of fuel used, multivariate logistic regression analysis was conducted, and adjustments were made for the covariables (passive smoking and occupational exposure to dust) using the Mantel-Haenszel chi-square test. Two-tailed Student's t-tests were used to determine the means of the spirometry measurements among the women in the two groups, and values of $p < 0.05$ were considered statistically significant.

Table 1 - Demographic characteristics of the subjects according to the type of fuel used for cooking.[a]

Characteristic	Biomass fuel	Non-biomass fuel	Total
	(n = 161)	(n = 108)	(n = 269)
Age bracket, years			
35-44	13 (8.1)	18 (16.7)	31 (11.5)
45-54	23 (14.3)	10 (9.3)	33 (12.3)
55-64	102 (63.4)	69 (63.9)	176 (63.6)
65-74	10 (6.2)	7 (6.5)	17 (6.3)
> 74	13 (8.1)	4 (3.7)	17 (6.3)
Level of education			
Good	9 (5.6)	19 (17.6)	28 (10.4)
Poor	152 (94.4)	89 (82.4)	241 (89.6)
Socioeconomic status			
Upper/ middle	10 (6.2)	6 (5.6)	16 (5.9)
Low	151 (93.8)	102 (94.4)	253 (94.1)

[a]Values expressed as n (%).

The study was approved by the Research Ethics Committee of the Federal Medical Center in the settlement of Ido-Ekiti.

Results

Of the 307 women who were recruited to participate in the study, 269 (87.6%) met the inclusion criteria and were included. The mean age of the participating women was 55 ± 10 years. Of the 269 participants, 241 (89.6%) had a low level of education, and 253 (94.1%) were

Table 2 - Respiratory symptoms reported by the women in the study, according to the type of fuel used for cooking.[a]

Respiratory symptom	Biomass fuel	Non-biomass fuel	Total
	(n = 161)	(n = 108)	(n = 269)
Cough	22 (13.7)	4 (3.7)	26 (9.7)
Wheezing	14 (8.7)	3 (2.8)	17 (6.3)
Chest pain	12 (7.5)	2 (1.9)	14 (5.2)
Breathlessness	19 (11.8)	7 (6.5)	26 (9.7)
Nasal symptoms	15 (9.3)	5 (4.6)	20 (7.4)
Chronic bronchitis	17 (10.6)	3 (2.8)	20 (7.4)

[a]Values expressed as n (%).

Table 3 - Risk of respiratory symptoms among women using biomass fuel.

Respiratory symptom	Adjusted OR*	95% CI	p
Cough	4.82	1.44-16.1	0.01
Wheezing	3.82	0.83-17.54	0.09
Chest pain	2.22	0.60-8.20	0.23
Breathlessness	1.54	0.26-1.62	0.35
Nasal symptoms	2.32	0.63-8.55	0.20
Chronic bronchitis	3.75	1.07-13.16	0.04

*Adjusted for passive smoking and occupational exposure to dust.

classified as being of low socioeconomic status, which was attributed to their level of education and occupation. The demographic characteristics of the study population are given in Table 1. Regarding the cooking fuel, 156 (58.0%) of the participants used firewood, 3 (1.1%) used dung/agricultural waste, and 2 (0.7%) used charcoal. Therefore, 161 women (59.9%) used BMFs, whereas 108 (40.1%) used a non-BMF (kerosene). None of the women used electricity or gas. Our results also showed that the women who used BMFs, when compared with those who used a non-BMF, more often reported symptoms of cough (13.7% vs. 3.7%), wheezing (8.7% vs. 2.8%), chest pain (7.5% vs. 1.9%), breathlessness (11.8% vs. 6.5%), and nasal symptoms (9.3% vs. 4.6%; Table 2). Of the 269 participants, only 20 (7.4%) met the case definition of chronic bronchitis. The multivariate logistic regression analysis showed that the women using BMFs were more likely to report respiratory symptoms and symptoms of chronic bronchitis than were those using a non-BMF (Table 3). A total of 99 women reported for baseline spirometry: the results were reliable in 79; and poor, unreliable results were obtained in 20. Of those who had reliable results, 49 used a non-BMF for cooking, and 30 used BMFs. All of the spirometric measurements were lower among the women who used BMFs than among those who used a non-BMF, and these differences were statistically significant for all variables except PEF and the FEV_1/FVC ratio (Table 4).

Table 4 - Spirometry parameters according to the type of fuel used for cooking.[a]

Parameter	Biomass fuel (n = 30)	Non-biomass fuel (n = 49)	p*
FEV_1, L	1.77 ± 0.49	2.25 ± 0.69	0.001
FEV_1, % of predicted	70.8 ± 9.50	80.7 ± 15.20	0.002
FVC, L	1.96 ± 0.52	2.44 ± 0.75	0.003
FVC, % of predicted	78.4 ± 11.2	86.8 ± 16.10	0.014
FEV_1/FVC, %	90 ± 11.46	92 ± 10.89	0.447
PEF, L/min	286 ± 85	325 ± 116	0.116
PEF, % of predicted	67.8 ± 19.10	78.2 ± 21.10	0.031

[a]Data expressed as mean ± SD. *Two-tailed p value based on Student's t-test.

Discussion

The results of our study show that 59.9% of the participants used BMFs, firewood accounting for 96% and dung accounting for only 1.1%. The high rate of BMF use is attributable to the fact that BMFs are the cheapest and most accessible sources of energy available to the rural women. In Nigeria, gas and electricity are not widely used because of their cost and, in the case of electricity, unreliability of supply, which has been a problem for more than a decade. We can assume that economic factors played the greatest role in our study sample, since the majority of the participating women had a low level of education (94.4%) and were of low socioeconomic status (93.8%). The role of socioeconomic status as a determinant of the type of cooking fuel used in the household has been described in other studies in developing countries.[14,15] According to one group of authors,[16] individuals tend to choose better and safer sources of energy as socioeconomic conditions improve. Our results also show that respiratory symptoms (cough, wheezing, chest pain, breathlessness, and nasal symptoms) and chronic bronchitis were more common in women using BMFs than in those using a non-BMF. This finding is similar to those of other studies.[16-20] The increased frequency of respiratory symptoms and chronic bronchitis can be attributed to toxic substances released during the combustion of BMFs. The inefficient burning of BMFs, in open fires or traditional stoves, generates large amounts of particulate matter, as well as CO, hydrocarbons, organic oxygen compounds, free radicals, and chlorinated organic compounds.[4] These toxic substances have been known to cause a decrease in mucociliary clearance and alveolar macrophage response, as well as suboptimal local immunity.[16]

In addition, the acute inhalation of BMF smoke causes acute bronchial irritation, inflammation, and bronchial reactivity, whereas long-term exposure causes chronic airway inflammation, as well as increasing susceptibility to bacterial and viral lung infections.[16] The multivariate logistic regression analysis showed that women using BMFs were five times more likely to report cough and four times more likely to have chronic bronchitis, and these associations were statistically significant ($p < 0.05$). Our results support those of other studies.[9,10,18,20-22] Other respiratory symptoms have been associated with the use of BMF, although the risks were not significant. Among the 79 women who had reliable spirometry results, all of the measurements were lower in those using BMFs than in those using a non-BMF. These differences were significant for all of the spirometry parameters except the FEV_1/FVC ratio and PEF. Our findings are similar to those of studies conducted in Ecuador and China, in which impaired pulmonary function in children was associated with exposure to indoor air pollution from BMF combustion.[23,24] The effects of BMF smoke on pulmonary function, as well as its association with obstructive and restrictive lung diseases, in adults have been well documented.[25-28] In animal models, exposure to toxic particulate matter has been associated with reduced lung compliance and decreased ventilatory response.[2,16] The use of BMFs for cooking has been described as a source of enjoyment for many women, and even a passion for some; unfortunately, it is a known health hazard.[29] We have attempted to determine whether the use of BMFs is associated with respiratory symptoms and chronic bronchitis. Our study was limited by our inability to measure indoor emissions, indoor concentrations, and personal exposure. Further studies should be carried out with more emphasis on those aspects, as well as on the levels of pollutants and the air exchange rate (ventilation).

The use of BMFs increases the risk of developing respiratory symptoms and chronic bronchitis. The results of our study underscore the need for women using BMFs to change their source of household energy—from toxic BMFs to cleaner, nontoxic types of fuel, such as electricity or gas. The government should also assist the population in shifting to cleaner fuels by subsidizing the costs of non-BMFs and ensuring a constant supply of electricity.

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