Effects of cooking fuel smoke on respiratory symptoms and lung function in semi-rural women in Cameroon

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Background: Indoor air pollution is a major health problem in the developing world. In sub-Saharan Africa more than 90% of people rely on biomass to meet their domestic energy demands. Pollution from biomass fuel ranks 10th among preventable risk factors contributing to the global burden of diseases.
Objectives: The present study aimed to determine the prevalence of respiratory symptoms and the factors associated with reduced lung function in a population of women exposed to cooking fuel smoke.
Methods: A cross-sectional study was conducted in a semi-rural area in Cameroon. We compared forced respiratory volume between women using wood (n=145) and women using alternative sources of energy (n=155) for cooking.
Results: Chronic bronchitis was found in 7.6% of the wood smoke group and 0.6% in the alternative fuels group. We observed two cases of airflow obstruction in the wood smoke group. Factors associated with lung function impairment were chronic bronchitis, use of wood as cooking fuel, age, and height.
Conclusion: Respiratory symptoms and reduced lung function are more pronounced among women using wood as cooking fuel. Improved stoves technology should be developed to reduce the effects of wood smoke on respiratory health.

Keywords: Indoor air pollution, Cooking smoke, Biomass, Africa, Wood smoke

Introduction

Approximately half of the world's population rely on biomass and coal as the main sources of energy for cooking, heating, and lighting.[1–3] The burning of biomass is associated with high levels of indoor air pollution and is considered as a major health concern in the developing countries, with an estimated two million people a year dying prematurely from illness attributable to indoor air pollution from solid fuels.[4] Among these deaths, 44% are due to pneumonia, 54% from chronic obstructive pulmonary disease (COPD), and 2% from lung cancer.[5]

Smoking, the primary risk factor for COPD worldwide, has a low prevalence in developing countries, but recent data show that smoking prevalence is increasing in these countries, especially among women.[6,7] Prior research found that women exposed to heavy indoor smoke are three times more likely to suffer from COPD compared to women using cleaner fuels (and therefore exposed to less indoor air pollution).[5] A randomized trial in Guatemala revealed a significant reduction in negative respiratory symptoms among women using improved indoor woodstoves.[8]

In sub-Saharan Africa, where the majority of women rely on biomass fuel, the burden of related respiratory diseases has not been determined. A recent review on the effects of indoor air pollution in low- and medium-income countries revealed few studies conducted in African countries.[9] In Malawi, individuals using wood as their primary domestic fuel had significantly more impaired lung function compared with those using charcoal.[10] In that study, age, gender, height, wood smoke exposure, poverty, smoking, and a history of tuberculosis were all associated with impaired lung function. Another study in Côte d'Ivoire focused on respiratory symptoms without any evaluation of lung function.[11] To the best of our knowledge, in Cameroon, a country with a low prevalence of smoking, no studies

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DOI 10.1179/2049396714Y.0000000090

have been conducted to evaluate the relationship between biomass fuel-associated indoor pollution and respiratory symptoms.[12]

Methods

Study setting

This study was conducted in the Mifi division in the west region of Cameroon. Approximately 300 000 people live in the Mifi division, primarily in semi-rural and urban areas.[13]

Study design and participants

We carried out a cross-sectional study between March 2012 and July 2012 in the semi-rural area of Bafoussam. Households (all without postal codes) in this area were divided into four sections. Each household was assigned an identification number and in each of the four sections, 10 households were randomly selected for the study. Eligibility criteria included being female, at least 40 years old, and responsible for household cooking. Women self-reporting acute respiratory or cardiac conditions were excluded. The purpose of the study was explained to all potential participants and informed consent was obtained. All participants completed an individual interview that enquired about symptoms related to chronic lung disease. Participants were divided into two groups: (1) women exclusively exposed to wood smoke and (2) women exposed to alternative fuels, including charcoal, gas, and electricity while cooking. The study was approved by the National Ethics committee of Cameroon.

Variables and measurements

Two research assistants administered the questionnaire and one trained assistant administered the spirometric tests. Participants who had difficulty understanding or speaking French or English were interviewed in the local language. The primary outcome variable was forced expiratory volume in 1 second (FEV1). Secondary outcomes included respiratory symptoms (cough, dyspnea, phlegm) and airway obstruction (post bronchodilator FEV1/Forced Vital Capacity (FVC) $<70\%$) as defined by the Global Initiative for Obstructive Lung Disease.[14] Chronic bronchitis was defined as the presence of cough and sputum production for at least 3 months for two consecutive years. Potential confounders measured included smoking history, age, gender, and previous pulmonary tuberculosis.

After the interview, height and weight were measured and participants were instructed how to complete the spirometer test (using Spirobank II). Each maneuver was performed at least three times to meet reproducibility criteria, and the best curve was selected for analysis. For patients having FEV1/FVC below 70%, the spirometry was repeated 15 minutes after inhalation of 400 μg of Salbutamol. All the spirometric graphs were reviewed by a pulmonologist to verify the reproducibility and the acceptability of curves according to American Thoracic Society (ATS) guidelines.[15]

Statistical methods

Data were analyzed using the Statistical Package for Social Sciences (SPSS) Version 17.0. Descriptive statistics included proportions for categorical variables and medians or means for continuous variables. For the comparison of continuous variables, the student-*t* test or Mann–Whitney *U* test were used. Factors associated with the primary outcome variable (FEV1) were identified using simple linear regression analysis. Variables with $P<0.20$ were then included in the multiple linear regression analysis for the assessment of the independent effect of individual factors and potential confounders. A *P*-value <0.05 was considered statistically significant.

Results

A total of 300 subjects were enrolled in the study and 262 (87.3%) had acceptable spirometric measurements. Demographic characteristics of the study population are shown in Table 1. Among participants, 145 (48.3%)

Table 1 Participant characteristics ($n=300$)

Characteristics	Description	Wood users $N=145$	Other fuel users $N=155$	*P* value
Age (years)	Median (IQR)	53 (47.5–59)	49 (44–53)	0.000
	40–49	45 (31%)	79 (51%)	
	50–59	66 (45.5%)	63 (40.6%)	
	60–69	26 (17.9%)	9 (5.8%)	
	≥70	8 (5.5%)	4 (2.6%)	
School education		115 (79.3%)	152 (98.1%)	0.000
Smoking status		1 (0.7%)	1 (0.6%)	0.62
Pet animals at home		43 (29.7%)	81 (52.3%)	0.000
Knowledge of harmful effects of wood smoke		25 (17.2%)	77 (49.7%)	0.000
Kitchen location	Indoor	0	18 (11.6%)	
	Outdoor	145 (100%)	5 (3.2%)	
	Both	0	132 (85.2%)	
Cooking smoke exposure (years)	Median (IQR)	40 (40–45.5)	35 (30–40)	0.000
Cooking smoke exposure (hours)	Median (IQR)	2 (2–3)	2 (2–3)	0.31

IQR: Interquartile range.

exclusively used wood as cooking fuel and 155 (51.7%) used an alternative source of energy for cooking. The median age of women exposed to wood smoke (53 years, IQR 47.5–59) was higher than those of the alternative fuel group (49 years, IQR 44–53) (P= 0.000). The prevalence of smoking in both groups was, respectively, 0.7 and 0.6%. Duration of exposition in the two groups was 40 years (IQR 40–40.5) for the wood smoke group and 35 years (IQR 30–40) for the other fuels users (P=0.000). Women in both groups were exposed to cooking smoke for approximately 2 hours (IQR 2–3) a day.

Women exposed to wood smoke (Table 2) had a higher prevalence of chronic bronchitis (7.6%) compared to the alternative fuel group (0.6%) (P=0.002). Spirometric values were analyzed for 262 subjects [38 women (12.7%) had unacceptable readings]. The median value of FEV1 (2315 ml, IQR 2135–2662) was significantly higher among women using alternative sources of cooking energy compared to women in the wood smoke group (2085 ml, IQR 1742–2425). There were two cases (1.6%) of COPD among women using wood and no cases in the alternative fuel group.

Univariate analysis (Table 3) revealed significant associations between lung function impairment and educational attainment, knowledge of smoking related diseases, chronic bronchitis, dyspnea, cooking fuel, age, and height. After adjustment in the multiple linear regression model, we found significant associations between lung function impairment and chronic bronchitis, cooking fuel, age, and height of participants.

Discussion

We determined the prevalence of respiratory symptoms and reduced lung function and identified factors associated with lung function impairment among women exposed to indoor pollution from biomass combustion in Cameroon. Our results indicate that the main respiratory symptoms related to using wood as a cooking fuel were dyspnea on exertion and chronic cough suggestive of chronic bronchitis. In addition, we found 2 cases of COPD and 13 cases of restricted lung function. We also demonstrated a statistically significant association between reduced FEV1 and the type of cooking fuel, chronic bronchitis, age, and height. Our results suggest that interventions promoting the use of improved stoves in this community would be effective in reducing indoor pollution respiratory diseases.

Table 2 Clinical characteristics of participants (n=300)

Characteristics	Wood users N=145	Other fuel users N=155	P value
Chronic bronchitis	11 (7.6%)	1 (0.6%)	0.002
Dyspnea on exertion	32 (22.1%)	8 (5.2%)	0.0001
FEV1 (IQR)	2085 (1742–2425)	2315 (2135–2662)	0.001
FVC (IQR)	2490 (2072–2850)	2740 (2427–3040)	0.001
Restriction (FEVI/FVC>70% and FEV1 or FVC<80% predicted)	9 (7.6%)	3 (2.2%)	0.04
Airway obstruction (FEV1/FVC<70%)	2 (1.6%)	0	0.21

Chronic bronchitis: presence of cough and sputum production for at least 3 months during two consecutive years.

Table 3 Univariate and multivariate analysis of factors associated with lung function impairment

Variables	Mean FEV1 (ml)	Unadjusted mean difference in FEV1 (95%CI)	P value	Adjusted mean difference in FEV1 (95%CI)	P value
School education					
No	1735	−536 (−332 to −740)	0.000	−115 (−280 to 49)	0.16
Yes (Ref.)	2272				
Pet animals					
Yes	2284	96 (−13 to −205)	0.08	−14 (−98 to 70)	0.74
No (Ref.)	2188				
Knowledge of smoking related diseases					
No	2163	−188 (−300 to −76	0.001	−74 (−14 to 163)	0.10
Yes (Ref.)	2351				
Chronic bronchitis					
Yes	1495	−745 (−1179 to −311)	0.001	−370 (−703 to −38)	0.029
No (Ref.)	2240				
Dyspnea on exertion					
Yes	1962	−302 (466 to −137)	0.000	−54 (−190 to 82)	0.43
No (Ref)	2264				
Cooking fuel					
Wood	2085	−273 (−378 to −168)	0.000	−120 (−205 to −35)	0.005
Others (Ref)	2358				
Age per year increase	–	−33 (−39 to −28)	0.000	−27 (−32 to −21)	0.000
Height per cm increase	–	30 (23–38)	0.000	18 (12–25)	0.000

While published studies of respiratory diseases associated with indoor pollution from biomass fuel are available, there are few from Africa. Twenty years ago, Smith *et al.* found that 4.5 hours of exposure to wood smoke is equivalent to smoking approximately 20 packs of cigarettes per day.[16] In industrialized countries, COPD is attributed to cigarette smoking, whereas in the developing world, biomass combustion is an important risk factor for COPD, especially in rural areas. In Latin America and Asia, studies have found an association of exposure to solid fuel smoke with COPD and chronic bronchitis, especially in women.[1,17–21] In Sub-Saharan Africa, a study conducted by Fullerton in Malawi reported a COPD prevalence of 16%, higher than this study (1.6% among wood users).[10] The difference in results may be explained by the fact that the Malawian study included men and women whereas our study population comprised only women. Moreover, the prevalence of former and current smokers was 28% in Malawi and only 0.7% in our study. These two factors likely contributed to the high prevalence of COPD reported in Malawi. Interestingly, other authors have reported that exposure to cooking fuel smoke in developing countries was consistently associated with chronic bronchitis, while effects on pulmonary function tests were variable or small, similar to the results of the present study.[22–24]

Previous studies have demonstrated the mechanism of broncho-pulmonary involvement during wood smoke exposure. Inflammation of bronchial epithelium, diffuse parenchymal anthracotic deposits, as well as inflammatory and fibrous thickening of the alveolar septa are described as the main pathological findings in the lungs of patients with chronic exposure to wood smoke.[25,26] In an experimental study on guinea pigs, Ramos *et al.* concluded that subchronic exposure to wood smoke produces effects similar to tobacco smoke, showing inflammatory lesions comparable to emphysema and accompanied by an increase in matrix metalloproteinase activity and expression, as well as apoptosis.[27] The presence of these enzymes in the respiratory tract seems to be responsible for degradation of the basement membrane and interstitial extracellular matrix. Another study suggested that oxidant production and neutrophilic inflammation are associated with wood smoke-induced lung injury.[28]

One limitation of this study is that 38 subjects could not perform spirometry. Twenty-five of those unable to perform spirometry were in the wood smoke exposure group, possibly resulting in an underestimation of the number of women with decreased FEV1. Despite this limitation, the comparison of two groups in this study provides important data for Africa regarding the association between biomass fuel and respiratory diseases.

In conclusion, we demonstrated an association between indoor pollution from cooking fuel and respiratory symptoms, including decreased lung function. From an epidemiological point of view, wood fuel burning is a modifiable cause of respiratory disease in developing countries. Healthcare workers and users of biomass fuel should be sensitized on the negative impact of indoor pollution on respiratory health. Health and policy advocates should promote clean fuel cooking technology to reduce the burden of respiratory diseases in Cameroon.

Disclaimer Statements

Contributors Mbatchou Ngahane Bertrand Hugo contributed in concept, design, definition of intellectual content, literature search, data acquisition, data analysis, statistical analysis, manuscript preparation, manuscript editing, and manuscript review. Afane Ze Emmanuel contributed in concept, design, definition of intellectual content, manuscript editing, and manuscript review. Temfack Elvis, Mapoure Njankouo, Nganda Malea and Luma Namme Henry reviewed the manuscript. CHEBU Cyrille did data acquisition.

Funding None.

Conflicts of interest The authors declare no conflicts of interest.

Ethics approval We received the ethical approval.

Acknowledgments

The authors thank the Pan African Thoracic Society MECOR course staff and the Douala Research Network for their suggestions during the preparation of the manuscript.

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