Clinical Medicine and Health Research Journal (CMHRJ)
Volume 02, Issue 05, September - October, 2022
Page No. 226-233

Research Article

Spirometric Indices of Charcoal Smoke Exposed Food Grillers in Yenagoa South-South, Nigeria

Onini E. Nathan[1], Jumbo Johnbull[2], Edafe A. Emmanuel[2], Ikuabe O. Peter[2], Erhabor E.Gregory[3]

[1]Department of Internal Medicine, Federal Medical Centre Yenagoa Bayelsa State Nigeria

[2]Department of Internal Medicine, Faculty of Clinical Sciences Niger Delta University Wilberforce Island Bayelsa State Nigeria

[3]Department of Internal Medicine, Obafemi Awolowo University Ile-Ife Osun State Nigeria

Received: 20 August, 2022 Accepted: 25 September, 2022 Published: 29 September 2022

Abstract:

Background: Pulmonary function is an important marker of the effects of air pollution on the exposed population.

Mild to moderate reductions of FEV_1/FVC, FEV_1, $FEV_1\%$, PEF, and $FEF_{25–75}$ have been associated with the exposure to biomass burning in cross-sectional studies. Some hospital-based case-control studies, confirm that people exposed to biomass smoke have high risk for developing airflow obstruction with significant reduction of FEV_1 and FEV_1/FVC.

However, none of these studies has evaluated lung function parameters among charcoal smoke exposed food grillers.

Therefore this index study took a look at spirometric indices among food grillers exposed to charcoal smoke in Yenagoa, South-South Nigeria.

Methods: This was a comparative observational cross-sectional study of charcoal smoke exposed spirometric indices of food grillers compared to fruit sellers

The Medical Research Council (MRC) Questionnaire was administered to participants and a "one-on-one" interview was conducted by the researcher using the questionnaires.Information obtained included socio-demographic characteristics such as age, gender, marital status and level of education.

Spirometry was performed in accordance with the ATS/ERS using standard single reusable turbine spirometer (MIR Spirobank II Basic; manufactured by P & A Medical Limited). Spirograms that met the ATS/ERS criteria for acceptability were used.

Information obtained with the spirometer were FEV_1, FVC, FEV_1/FVC, PEF and FEF_{25-75}.

A portable HANA analogue weight machine was used to weigh the study participants and a flexible plastic tape measure was used to measure the heights of participants

Results: A total of one hundred and sixty (160) participants made up of eighty (80) food-grillers and fruit-sellers (controls) respectively were recruited for this study.

A normal lung function pattern was found in 60 (75.0%) of food-grillers and 72 (90.0%) of controls. This shows that more fruit-sellers had normal lung function pattern, and this was statistically significant ($p = 0.013$). Obstructive pattern was found in 16 (20.0%) of food-grillers and 6 (7.5%) of controls ($p = 0.022$).

The mean lung function values for food-grillers compared to fruit sellers were: FEV_1=2.8±0.5L vs 3.2±0.5 (72.3±5.8% predicted); FVC=3.6±0.6L vs 3.9±0.8 (76.8±6.6% predicted), FEV_1/FVC=78.5±4.9 vs 85.3 ±5.3 (77.1±5.4% predicted); PEF=5.7± 1.2L/s vs 6.9 ±2.9 (81.6±7.3% predicted) and FEF_{25-75}=2.8±0.8L/s vs 3.0 (±0.4) (80.5±15.3% predicted). The values were statistically different between food-grillers and controls ($p < 0.001$).

Conclusion:

1. Exposure to charcoal smoke is associated with the development of lung function abnormalities and reduction in lung function parameters.
2. Increasing exposure time to charcoal smoke increase the likelihood of lung function abnormalities.

Keywords: Spirometric indices, food grillers, charcoal smoke.

Background

Pulmonary function is an important marker of the effects of air pollution on the exposed population, as well as being an early, objective, and quantitative predictor of cardiorespiratory disease and death.[1] Studies have demonstrated both acute and chronic decline in lung function with exposure to air pollutants in children, adolescents, healthy adults, and individuals with a history of respiratory disease.[1]Mild to moderate reductions of

FEV_1/FVC, FEV_1, $FEV_1\%$, PEF, and $FEF_{25–75}$ have been associated with the exposure to biomass burning in cross-sectional studies.[2,3]
Other studies, mainly hospital-based case-control studies, confirm that people exposed to biomass smoke have high risk for developing airflow obstruction with significant reduction of FEV_1 and FEV_1/FVC.[4,5,6]Maternal exposure to biomass smoke has been associated with low birth weight in infants,[7]with possible impairment of lung growth and development and impact on adult respiratory function and diseases.
A cross-sectional comparative study by ObiebiIP, et al, showed lung function impairment among charcoal workers and matched controls in an informal occupational setting in southern Nigeria.[8]
A study by Olujimi OO, et al, on air quality index from charcoal production sites, carboxyhaemoglobin and lung function among exposed charcoal workers in south western Nigeria showed that charcoal workers are exposed to high levels of CO and PM2.5, contributing to lowered respiratory functions for FEV1 and PEFR and high levels of COHb compared to the control group.[9]
Another study by Ofori SN, et al demonstrated association between choice of cooking fuel and abnormal peak expiratory flow rate(PEFR) among rural women in the Niger Delta.[10]
However, none of these studies has evaluatedlung function parameters among charcoal smoke exposed food grillers.
Therefore, this index study is taking a look at spirometric indices among food grillers exposed to charcoal smoke in Yenagoa, South-South Nigeria.

Materials and Method

The study was conducted in Yenagoa, the capital city of Bayelsa State, South-South, Nigeria. The city has an estimated population of 24,335 inhabitants with people of Ijaw ethnic extraction as the dominant percentage of the population.
Bayelsa is essentially a civil service state and there are no industrial activities in Yenagoa, where this study was conducted. Majority of the population of Yenagoa is made up of civil servants.
The sample size was rounded off to a total of 80 persons for the study. Also, an equal number of fruit-sellers were recruited as controls, making the total sample size to be 160.
Two-stage cluster sampling was used to recruit participants to make up the desired sample size of 160 participants, eighty (80) each, for food-grillers and controls.

Inclusion criteria for food-grillers:

1. Current use of wood charcoal for food-grilling for at least four (4) weeks.
2. Adults between 18 – 60 years who gave consent.

Exclusion criteria for food-grillers:

1. Age less than 18 years or above 60 years.
2. Use of energy sources other than wood charcoal for food-grilling.
3. History of chronic lung disease prior to working as food-griller.
4. Previous or current cigarette smoking.
5. Engagement in other occupations that cause air pollution such as road construction work, painting, road traffic officer, petroleum worker, etc.

Inclusion criteria for controls:

1. Fruit-sellers between 18 – 60 years who gave consent.

Exclusion criteria for controls:

1. Age less than 18 years and above 60 years formed a total of 160 participants, eighty (80) each, for food-grillers and controls.
2. Use of energy sources other than wood charcoal for food-grilling.
3. History of lung disease.
4. Previous or current cigarette smoking.
5. Engagement in other occupations that cause air pollution such as road construction work, painting, road traffic officer, petroleum worker, etc.

Inclusion criteria for controls:

1. Fruit-sellers between 18 – 60 years who gave consent.

Exclusion criteria for controls:

1. Age less than 18 years and above 60 years.

The Medical Research Council (MRC) Questionnaire[11] was administered to participants and a "one-on-one" interview was conducted by the researcher using the questionnaires. Information obtained included socio-demographic characteristics such as age, gender, marital status and level of education. Other information obtained with the questionnaire were respiratory symptoms such as cough, shortness of breath, production of phlegm, chest pain, chest tightness and wheeze as well as smoking and alcohol history. Additional information in the questionnaire were source of energy for domestic cooking, limitation of daily activities and sleep, and information on duration of food-grilling with charcoal.

Spirometer:

A standard single reusable turbine spirometer (MIR Spirobank II Basic; manufactured by P & A Medical Limited) was used to assess lung function in the participants. Information obtained with the spirometer were FEV_1, FVC, FEV_1/FVC, PEF and FEF_{25-75}.

Weight machine:

A portable HANA analogue weight machine was used to weigh the study participants.

Tape measure:

A flexible plastic tape measure was used to measure the heights of participants.

Pulse oximeter:

A portable pulse oximeter (Gurin Finger Pulse Oximeter) was used to measure oxygen saturation and pulse rates of the study participants.

Procedure:

Spirometry was performed in accordance with the ATS/ERS.[12]Spirograms that met the ATS/ERS criteria for acceptabilitywere used.

The highest of three spirograms which meet the acceptability criteria was chosen for evaluation of lung function.

The following measurements were obtained from spirometry:

a. **FEV_1:** Forced Expiratory Volume in one second, defined as the maximal volume of air forcefully exhaled in the first second from total lung capacity.[13]
b. **FVC:** Forced Vital Capacity, defined as the maximal volume of air forcefully exhaled following maximal inspiration.[13]
c. **FEV_1/FVC:** Ratio of FEV_1 to FVC.[13]
d. **PEF:** Peak Expiratory flow, defined as the maximum flow rate generated during a forceful exhalation, starting from total lung capacity.[13]**FEF_{25-75}:** Forced expiratory flow at 25-75% of FVC, otherwise known as Maximum Mid Expiratory flow (MMEF).[13]

The lung function patterns assessed were:

- **Normal:** FEV_1/FVC > 0.7 with normal FEV_1 and FVC.
- **Obstructive:** FEV_1/FVC < 0.7.
- **Restrictive:** FEV_1/FVC normal or high with reduced FEV_1 and FVC.
- **Mixed:** FEV_1/FVC < 0.7 with both FVC and FEV_1 reduced.
- **ETHICAL CONSIDERATIONS**

Ethical approval for the study was obtained from the Research and Ethics Committee (REC) of the Niger Delta University Teaching Hospital (NDUTH), Okolobiri.

Results

A total of one hundred and sixty (160) participants made up of eighty (80) food-grillers and fruit-sellers (controls) respectively were recruited for this study. Table 1 shows that the mean age was 34.5±9.5 years for food-grillers and 33.5±7.6 years for controls. Most of the study population were females (55, 68.7% for food-grillers and 61, 76.2 for controls). The average number of years of food-grilling was 5.1 (± 3.7) years and 5.8 (± 3.6) years for controls (t = 1.27). There was no statistical difference in the duration of each occupation (p value = 0.206)

Table 1: Sociodemographic characteristics

Characteristics	Total	Food Grillers	Fruit Seller	χ^2	df	pValue
	N = 160 (%)	N = 80 (%)	N = 80 (%)			
Sex						
Male	44 (27.5)	25 (31.3)	19 (23.8)	1.13	1	0.288
Female	116 (72.5)	55 (68.7)	61 (76.2)			
Age group						
< 25 years	15 (9.4)	10 (12.5)	5 (6.3)	4.95	4	0.292
25 – 34 years	72 (45.0)	31 (38.8)	41 (51.2)			
35 – 44 years	55 (34.4)	28 (35.0)	27 (33.8)			
45 – 54 years	13 (8.1)	7 (8.8)	6 (7.5)			
≥ 55 years	5 (3.1)	4 (5.0)	1 (1.3)			
Mean Age (±SD) in years	34.0 (8.6)	34.5 (± 9.5)	33.5 (± 7.6)	t = 0.69		0.493
Marital Status						
Single	82 (51.2)	32 (40.0)	25 (31.3)	8.22	3	0.042
Married	65 (40.6)	40 (50.0)	25 (31.3)			
Separated	7 (4.4)	4 (5.0)	3 (3.8)			
Widowed	6 (3.8)	4 (5.0)	2 (2.6)			
Religion						
Christian	129 (80.6)	57 (71.3)	72 (90.0)	9.00	1	0.003
Muslim	31 (19.4)	23 (28.7)	8 (10.0)			
Level of Education						
No formal Education	21 (13.1)	14 (17.5)	7 (8.8)	4.92	3	0.178
Primary	20 (12.5)	10 (12.5)	10 (12.5)			
Secondary	96 (60.0)	42 (52.5)	54 (67.5)			
Tertiary	23 (14.4)	14 (17.5)	9 (11.2)			
Duration of Practice of the trade						
1 – 5 years	94 (58.8)	50 (62.5)	44 (55.0)	1.46	2	0.481
6 – 10 years	50 (31.3)	24 (30.0)	26 (32.5)			
>10 years	16 (10.0)	6 (7.5)	10 (12.5)			
Mean Duration(SD) in years	5.5 (± 3.6)	5.1 (± 3.7)	5.8 (3.6)	t = 1.27		0.206

A normal lung function pattern was found in 60 (75.0%) of food-grillers and 72 (90.0%) of controls (table 2). This shows that more fruit-sellers had normal lung function pattern, and this was statistically significant (p = 0.013). Obstructive pattern was found in 16 (20.0%) of food-grillers and 6 (7.5%) of controls (p = 0.022).

Table 2: Lung Function patterns among food-grillers and Controls

Characteristics	Total	Food Grillers	Fruit Seller	χ^2	P Value
	N = 160 (%)	N = 80 (%)	N = 80 (%)		
Lung Function Pattern					
Normal	132 (82.5)	60 (75.0)	72 (90.0)	6.20	0.013*
Obstructive	22 (13.8)	16 (20.0)	6 (7.5)	5.27	0.022*
Restrictive	5 (3.1)	3 (3.8)	2 (2.5)	0.21	0.651
Mixed	1 (0.6)	1 (1.2)	0 (0.0)	0.01	0.316

* Statistically significant parameters

As shown in table 3, the mean lung function values for food-grillers were: FEV_1=2.8±0.5L (72.3±5.8% predicted); FVC=3.6±0.6L (76.8±6.6% predicted), FEV_1/FVC=78.5±4.9% (77.1±5.4% predicted); PEF=5.7± 1.2L/s (81.6±7.3% predicted) and FEF_{25-75}=2.8±0.8L/s (80.5±15.3% predicted). The lung function parameters and mean values for controls are also shown in table 3. The values were statistically different between food-grillers and controls (p < 0.001).

Table 3: Lung function Parameters

Parameter	Total	Food Grillers	Fruit Seller	t-Test	pValue
	Mean (±SD)	Mean (±SD)	Mean (±SD)		
Absolute values					
FEV_1(L)	3.0 (±0.6)	2.8 (±0.5)	3.2 (±0.5)	5.08	<0.001*
FVC (L)	3.7 (±0.7)	3.6 (±0.6)	3.9 (±0.8)	2.58	0.011*
FEV_1/FVC (%)	81.9 (±12.0)	78.5 (±4.9)	85.3 (±5.3)	3.69	<0.001*
PEF (L/s)	5.6(±1.7)	5.7(±1.2)	6.9 (±2.9)	9.35	<0.001*
FEF25-75 (L/s)	3.5 (±1.2)	2.8 (±0.8)	3.0 (±0.4)	6.97	<0.001*
Percentage predicted					
FEV_1(%)	80.8(±7.I)	72.3(±5.8)	86.7(±6.5)	4.17	<0.001*
FVC (%)	77.3(±5.8)	76.8(±6.6)	84.3(±5.1)	3.04	<0.001*
FEV_1/FVC (%)	80.4(±7.2)	77.1(±5.4)	88.1(±6.2)	3.78	0.012*
PEF (%)	82.8(±8.1)	81.6(±7.3)	90.4(±4.9)	8.22	<0.001*
FEF_{25-75}(%)	85.0(±12.6)	80.5(±15.3)	89.8(±10.8)	5.81	0.115

* Statistically significant parameters

Lung function abnormalities is significantly associated with the occupation of the participants in the study. The odds of having an abnormal lung function was 3 times more among food-grillers (OR – 3.0; 95%CI: 1.23 – 7.29; p – 0.015) when compared to the fruit-seller (Table 10). Other factors include increasing age (OR 1.05; 95%CI: 1.00 – 1.50; p – 0.050), BMI (OR – 1.16; 95%CI:1.01 – 1.34; p – 0.036), number of hours participants worked per day (OR – 1.35; 95%CI: 1.09 – 1.66; p – 0.004), number of days worked per week (OR – 0.33; 95%CI: 0.16 – 0.66; p – 0.002), concentration of $PM_{2.5}$ (OR – 1.04; 95%CI: 1.01 – 1.06; p – 0.013) and PM_{10} (OR – 1.03; 95%CI: 1.01 – 1.05; 0.015).

Table 4: Factors relating to the presence of lung function abnormalities

Independent Variable	B	OR	95%CI		pValue
			Min	Max	
Age	0.05	1.05	1.00	1.10	0.050*
BMI	1.51	1.16	1.01	1.34	0.036*
Food-grilling	1.10	3.00	1.23	7.29	0.015*
Hours per day	0.29	1.35	1.09	1.66	0.004*
Number days per week	-1.11	0.33	0.16	0.66	0.002*
Number of Years	0.03	1.03	0.93	1.15	0.578
$PM_{2.5}$	0.04	1.04	1.01	1.06	0.013*
PM_{10}	0.03	1.03	1.01	1.05	0.015*

* Statistically significant parameters

As shown in table 5 below, the mean lung function values for food-grillers were: FEV_1=2.8±0.5L (72.3±5.8% predicted); FVC=3.6±0.6L (76.8±6.6% predicted), FEV_1/FVC=78.5±4.9% (77.1±5.4% predicted); PEF=5.7± 1.2L/s (81.6±7.3% predicted) and FEF_{25-75}=2.8±0.8L/s (80.5±15.3% predicted). The lung function parameters and mean values for controls are also shown in table 5. The values were statistically different between food-grillers and controls ($p < 0.001$).

Table 5: Lung function Parameters

Parameter	Total	Food Grillers	Fruit Seller	t-Test	pValue
	Mean (±SD)	Mean (±SD)	Mean (±SD)		
Absolute values					
FEV_1(L)	3.0 (±0.6)	2.8 (±0.5)	3.2 (±0.5)	5.08	<0.001*
FVC (L)	3.7 (±0.7)	3.6 (±0.6)	3.9 (±0.8)	2.58	0.011*
FEV_1/FVC (%)	81.9 (±12.0)	78.5 (±4.9)	85.3 (±5.3)	3.69	<0.001*
PEF (L/s)	5.6(±1.7)	5.7(±1.2)	6.9 (±2.9)	9.35	<0.001*
FEF25-75 (L/s)	3.5 (±1.2)	2.8 (±0.8)	3.0 (±0.4)	6.97	<0.001*
Percentage predicted					
FEV_1(%)	80.8(±7.I)	72.3(±5.8)	86.7(±6.5)	4.17	<0.001*
FVC (%)	77.3(±5.8)	76.8(±6.6)	84.3(±5.1)	3.04	<0.001*
FEV_1/FVC (%)	80.4(±7.2)	77.1(±5.4)	88.1(±6.2)	3.78	0.012*
PEF (%)	82.8(±8.1)	81.6(±7.3)	90.4(±4.9)	8.22	<0.001*
FEF_{25-75}(%)	85.0(±12.6)	80.5(±15.3)	89.8(±10.8)	5.81	0.115

* Statistically significant parameters

Lung function abnormalities is significantly associated with the occupation of the participants in the study. The odds of having an abnormal lung function was 3 times more among food-grillers (OR – 3.0; 95%CI: 1.23 – 7.29; p – 0.015) when compared to the fruit-seller (Table 6). Other factors include increasing age (OR 1.05; 95%CI: 1.00 – 1.50; p – 0.050), BMI (OR – 1.16; 95%CI:1.01 – 1.34; p – 0.036), number of hours participants worked per day (OR – 1.35; 95%CI: 1.09 – 1.66; p – 0.004), number of days worked per week (OR – 0.33; 95%CI: 0.16 – 0.66; p – 0.002), concentration of $PM_{2.5}$ (OR – 1.04; 95%CI: 1.01 – 1.06; p – 0.013) and PM_{10} (OR – 1.03; 95%CI: 1.01 – 1.05; 0.015)

Table 6: Factors relating to the presence of lung function abnormalities

Independent Variable	B	OR	95%CI		pValue
			Min	Max	
Age	0.05	1.05	1.00	1.10	0.050*
BMI	1.51	1.16	1.01	1.34	0.036*
Food-grilling	1.10	3.00	1.23	7.29	0.015*
Hours per day	0.29	1.35	1.09	1.66	0.004*
Number days per week	-1.11	0.33	0.16	0.66	0.002*
Number of Years	0.03	1.03	0.93	1.15	0.578
$PM_{2.5}$	0.04	1.04	1.01	1.06	0.013*
PM_{10}	0.03	1.03	1.01	1.05	0.015*

* Statistically significant parameters

Discussion

This index study investigated the lung function patterns among the food grillers study population compared to the control. The study showed that majority of participants had a normal lung function pattern. However, of the abnormal lung function patterns, which were obstructive, restrictive and mixed patterns, more participants had obstructive lung function pattern than restrictive and mixed patterns respectively. This was more with food-grillers than the controls (20.0% vs 7.5%). The severity of airway obstruction was mild to moderate. It was also observed from the study that small airway obstruction as extrapolated from the percentage predicted of FEF_{25-75} was conspicuously more with food-grillers compared to controls (Table 3).

Several studies[14,15,16,17]have demonstrated an association between biomass fume exposure and the development of obstructive airway disease. One of the first associations of biomass smoke with obstructive lung disease was reported by Woolcock et al.[18]in New Guinea. Since then, many reports of this association have emerged from different parts of the world.[19-25]SanaA, et al. conducted a systematic review and meta-analysis[26] on chronic obstructive pulmonary disease associated with biomass fuel use in women. A total of 24 studies were analysed, and demonstrated significant association between biomass smoke exposure and COPD. In another study, Om PK, et alinvestigated reduced lung function due to biomass smoke exposure in young adults in rural Nepal. One of the conclusions drawn in that study was thatthe prevalence of airflow obstruction in the biomass smoke-exposed population was significantly higher than that in the non-biomass-exposed group.[27]

These studies all had similar findings with the current study. However, the cross-sectional comparative study conducted by Obiebi IP, et al, which examined lung function impairment among charcoal workers and matched controls in an informal occupational setting, reported that restrictive impairment was more prevalent in charcoal workers than controls.[8] The discrepancy in the findings can be accounted for by the fact that in the cited study, participants were strictly involved in production of wood charcoal. Charcoal production is associated with generation of significant amount of dust.[28,29]Therefore, they could risk exposure to more of charcoal dust rather than smoke compared with food-grillers, who were exposed to more of a mixture of charcoal smoke and other emissions from the grilled food. Dust inhalation is more likely to give rise to a pneumoconiosis, which is typically associated with a restrictive lung function pattern, rather than obstructive.

In the current study, it turned out that lung function parameters were significantly reduced among food-grillers compared with controls (Table 3). Various studies both within and outside Nigeria have consistently demonstrated that exposure to biomass emissions is associated with reduced lung function parameters[8,9,10,14]In one case-control study, Baran B and colleagues investigated the effects of biomass smoke on pulmonary function. These investigators noted lower lung function parameters among those exposed to biomass fumes.[30]Birsen O and co-workers, in a different study[31]evaluated the impact of exposure to biomass smoke vs cigarette smoke on serum inflammatory markers and pulmonary function parameters in patients with chronic respiratory failure (CRF). These researchers also concluded from their study that there were similarly increased inflammatory markers and abnormally low pulmonary function test findings in both biomass smoke exposure and cigarette smoke exposure groups, emphasizing that the adverse effects of biomass smoke exposure on lungs is as significant as cigarette smoke exposure.

This study also revealed significant relationship between lung function abnormalities and food-grilling as an occupation; food-grillers were about three (3) times more likely to develop abnormal lung function patterns than controls (Table 6). Other factors relating to the development of lung function abnormalities were increasing age, body mass index (BMI), number of hours at work per day, number of days worked per week.

One important factor to consider in the assessment of exposure to a substance, is the duration of exposure.[32,33]The more time an individual spends around the vicinity of a toxic substance, the more the exposure to the substance and the more the chances of being affected by the toxic effects of that substance. Therefore, the relationship between increasing number of hours and increasing number of days of food-grilling and lung function abnormalities, as was observed in the current study, was not surprising.

Conclusions

The following conclusions were drawn from the study:

3. Exposure to charcoal smoke is associated with the development of lung function abnormalities and reduction in lung function parameters.
4. Increasing exposure time to charcoal smoke increase the likelihood of lung function abnormalities.

Recommendations

From the study outcomes, the following recommendations were made:

1. An alternative source of energy such as electricity and liquefied natural gas should be used for food-grilling to minimize the emissions generated during the process.
2. Food-grillers using charcoal should use personal protective equipment such as face masks and face shields during their occupational activities to prevent the level of exposure to noxious emissions generated during the process. This should be backed up and enforced with government and WHO policies.
3. Food-grillers using charcoal should have regular medical check-ups, including periodic spirometry to assess their lung functions.
4. A larger study would be necessary to adequately assess the health implications of local food-grilling with charcoal.

Limitations

1. The study was limited to Yenagoa alone and may require a larger area to increase the strength.
2. Some measurements and investigations such as arterial blood gas and chest radiograph were not done due to financial constraints. These would probably have uncovered more findings in the study.

Acknowledgement

The authors wish to thank all the food grillers and the fruit sellers for participating in the study and for their cooperation. We also thank all staff of the respiratory unit and cardiorespiratory laboratory, Department of Internal Medicine, Niger Delta University Teaching Hospital, Okolobiri for their assistance.

References

1. Om PK, Grahanm SD, Cairns SS, Sean S, Markus FC, Padam S, et al. Reduced lung function due to biomass smoke exposure in young adults in rural Nepal. *European Respiratory Journal*, 2013; 41:25-30.
2. Saha A, Rao NM, Kulkarni PK, Majumdar PK, Saiyed HN. Pulmonary function and fuel use: a population survey. Respir Res 2005;6:127.
3. Regalado J, Perez-Padilla R, Sansores R, Paramo Ramirez JI, Brauer M, Pare P, Vedal S. The effect of biomass burning on respiratory symptoms and lung function in

rural Mexican women. Am J RespirCrit Care Med 2006;174:901–905.
4. Dennis RJ, Maldonado D, Norman S, Baena E, Martinez G. Woodsmoke exposure and risk for obstructive airways disease among women. Chest 1996;109:115–119.
5. Ekici A, Ekici M, Kurtipek E, Akin A, Arslan M, Kara T, Apaydin Z, Demir S. Obstructive airway diseases in women exposed to biomass smoke. Environ Res 2005;99:93–98.
6. Perez-Padilla R, Regalado J, Vedal S, Pare P, Chapela R, Sansores R, Selman M. Exposure to biomass smoke and chronic airway disease in Mexican women: a case-control study. Am J RespirCrit Care Med 1996;154:701–706.
7. Ozbay B, Uzun K, Arslan H, Zehir I. Functional and radiological impairment in women highly exposed to indoor biomass fuels. Respirology 2001;6:255–258.
8. Obiebi IP, Ibekwe RU, Eze GU. Lung function impairment among charcoal workers in an informal occupational setting in Southern Nigeria. *AJRM*. 2017; 13(1):140-145.
9. Olujimi OO, Ana GREE, Ogunseye OO, Fabunmi VT. Air quality index from charcoal production sites, carboxyhaemoglobin and lung function among occupationally exposed charcoal workers in South Western Nigeria. *Springerplus*. 2016; 5(1): 1546.
10. Umoh VA, Etete P. The relationship between lung function and indoor air pollution among rural women in the Niger Delta region of Nigeria. *Lung India*. 2014 Apr;31(2):110-5.
11. Cotes JE. Medical Research Council Questionnaire on Respiratory Symptoms. *Lancet*, 1987; 2(8566): 1028.
12. Brian LG, Irene S, Miller MR, Igor ZB, Brendan GC, Graham LH, et al. Standardization of spirometry 2019 update: An official American Thoracic Society and European Respiratory Society Technical Statement. *American Journal of Respiratory and Critical Care Medicine*, 2019; 200:8.
13. Moore VC. Spirometry: step by step. *Breathe*, 2012; 8: 232-240
14. Okwor TJ, Ozoh O, Okonkwo JI, Osibogun A. Occupational Exposure to Particulate Matter from Biomass Smoke and Its Relationship to Respiratory Symptoms and Pulmonary Function among Rural Women Involved in Cassava Processing in Nigeria. *Open Journal of Preventive Medicine*, 2017; 07(03):41-54.
15. Buist AS, McBurnie MA, Vollmer WM, Gillespie S, Burney P, Mannino DM, et al. International variation in the prevalence of COPD (the BOLD study): A population-based prevalence study. *Lancet*. 2007;370:741–750.
16. Gnatiuc L, Caramori G. COPD in nonsmokers: The biomass hypothesis - To be or not to be? *EurRespir J*. 2014;44:8–10.
17. Gordon SB, Bruce NG, Grigg J, Hibberd PL, Kurmi OP, Lam KB, et al. Respiratory risks from household air pollution in low-and middle-income countries. *Lancet Respir Med*. 2014;2:823–860.
18. Woolcock AJ, Blackburn CR, Freeman MH, Zylstra W, Spring SR. Studiesofchronic(nontuberculous)lungdiseaseinNewGuineapopulations.Thenatureofthedisease.Am.Rev.Respir.Dis.1970; 102: 575–590.
19. PandeyMR.Domesticsmokepollutionandchronicbronchitis in a rural community of the Hill Region of Nepal. Thorax 1984; 39: 337–339.
20. Malik SK. Exposure to domestic cooking fuels and chronic bronchitis. Indian J. Chest Dis. Allied Sci. 1985; 27: 171–174.
21. Menezes AM, Victora CG, Rigatto M. Prevalence and risk factors for chronic bronchitis in Pelotas, RS, Brazil: a population-based study. Thorax 1994; 49: 1217–1221.
22. Liu S, Zhou Y, Wang X, Wang D, Lu J, Zheng J, et al. Biomassfuelsaretheprobableriskfactorforchronicobstructive pulmonary disease in rural South China. Thorax 2007; 62: 889– 897.
23. EkiciA,EkiciM,KurtipekE,AkinA,ArslanM,KaraT, et al. Obstructive airway diseases in women exposed to biomass smoke. Environ. Res. 2005; 99: 93–98.
24. ZhongN,WangC,YaoW,ChenP,KangJ,HuangS, et al. Prevalence of chronic obstructive pulmonary disease in China: a large, population-based survey. Am. J. Respir. Crit. Care Med. 2007; 176: 753–760.
25. Orozco-Levi M, Garcia-Aymerich J, Villar J, Ramirez-Sarmiento A, Anto JM, Gea J. Wood smoke exposure and risk of chronic obstructive pulmonary disease. Eur. Respir. J. 2006; 27: 542–546.
26. Sana A, Somda SMA, Meda N, Bouland C, et al. Chronic Obstructive Pulmonary Disease Associated with Biomass Fuel Use in Women: a systematic review and meta-analysis. BMJ Open Respir Res, 2018; 5:e000246.
27. Om PK, Graham S, Devereux W, Cairns SS, Sean S, Markus FCS, et al. Reduced lung function due to biomass smoke exposure in young adults in rural Nepal. European Respiratory Journal, 2013; 41: 25-30.
28. Eduardo M, Eduardo A, Aantonieta MZ, Albina MA, Ferreira RG, Alipio BB, et al. Wood charcoal and activated carbon dust pneumoconiosis in three workers. Am J Med, 2007; 50 (3): 191-196.
29. Torres PPTS, Machiori E, Pinto SA, Rabahi MF, et al. Wood charcoal dust pneumoconiosis. Rev Port Pneumol. 2017; 23 (4): 233-234.
30. Balcan B, Akan S, Oszancak UA, Ozcelik HB, Bagci CB, et al. Effect of biomass smoke on pulmonary functions: a case control study. *International journal of chronic obstructive pulmonary disease*, 2016; 11 (1): 1615-1622.
31. Birsen O, Eylem A, Emine A, Sinem G, Fulya C, Selahattin O, et al. The impact of exposure to biomass smoke versus cigarette smoke on inflammatory markers and pulmonary function parameters in patients with chronic respiratory failure. *International journal of chronic obstructive pulmonary disease*, 2018; 13: 1261-1267.
32. Kodros JK, Carter E, Brauer M, et al. Quantifying the contribution to uncertainty in mortality attributed to

household, ambient, and joint exposure to $PM_{2.5}$ from residential solid fuel use. Geohealth, 2018; 2 (1): 25-39.

33. United States Environmental Protection Agency. Guidelines for Human Exposure Assessment, 2019.