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Original Research Article

Impact of Biofuel Smoke on Ventilatory Function among Food Vendors Exposed to Biomass in Maiduguri, Northeast Nigeria

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Abstract: ***Background***: Chronic exposure to biofuel smoke is a major risk factor for respiratory impairment in developing countries, yet its impact on ventilatory function and the role of exposure duration remain understudied in Northeast Nigeria. ***Objective***: The study aimed to evaluate ventilatory function parameters and the effect of exposure duration on lung function among commercial food vendors exposed to biofuel smoke in Maiduguri, Nigeria, compared to controls. ***Methods***: A cross-sectional study was conducted involving 182 food vendors using biofuels and 185 age-, sex-, and height-matched controls. Spirometry measured peak expiratory flow (PEF), forced expiratory volume in 1 second (FEV_1), forced vital capacity (FVC), and FEV_1/FVC ratio. Ventilatory defects (obstructive/restrictive) were defined using Global Lung Function Initiative Lower Limit of Normal criteria (LLN). Exposure duration was assessed via questionnaire. Groups were compared using t-tests and chi-square tests, with Pearson's correlation for exposure duration and lung function, at $p<0.05$. ***Results***: Vendors exhibited significantly lower PEF (5.95 ± 1.17 vs. 6.49 ± 1.12 L/s, $p<0.001$), FEV1 (2.39 ± 0.49 vs. 2.65 ± 0.49 L, $p<0.001$), FVC (3.10 ± 0.49 vs. 3.39 ± 0.54 L, $p<0.001$), and FEV1/FVC (76.72 ± 5.44% vs. 78.30 ± 4.26%, $p=0.002$) than controls. Obstructive defects were observed in 8.2% of vendors vs. 4.3% of controls ($p=0.13$); restrictive defects in 1.6% vs. 0.5% ($p=0.34$). Exposure duration negatively correlated with FEV1/FVC ($r=-0.23$, $p=0.002$). ***Conclusion***: Biofuel smoke exposure impairs ventilatory function, with longer exposure exacerbating airflow limitation, highlighting the need for occupational health interventions in Nigeria.

Keywords: Biofuel Smoke, Ventilatory Function, Spirometry, Exposure Duration, Food Vendors, Maiduguri, Nigeria.

INTRODUCTION

Chronic exposure to biomass smoke, generated from the combustion of solid fuels such as wood and charcoal, is a leading environmental health risk in low- and middle-income countries, contributing significantly to respiratory morbidity and mortality [1, 2] . Globally, approximately 3 billion people rely on biomass fuels for cooking and heating, resulting in household air pollution that the World Health Organization (WHO) estimates causes over 3.8 million premature deaths annually, primarily from respiratory and cardiovascular diseases [1]. In sub-Saharan Africa, where biomass fuels are a primary energy source for over 70% of households, the burden is particularly pronounced, with chronic obstructive pulmonary disease (COPD) and other respiratory conditions increasingly linked to prolonged smoke exposure [3, 4]. The combustion of biofuels produces a complex mixture of pollutants, including particulate matter (PM2.5, PM10), carbon monoxide (CO), nitrogen dioxide (NO2), and volatile organic compounds (VOCs),[5] which deposit in the lungs, triggering inflammatory responses mediated by cytokines such as IL-1β, IL-6, and TNF-α [6-9]. These

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inflammatory processes can lead to airway remodeling, emphysema, and reduced ventilatory function, manifesting as declines in peak expiratory flow (PEF), forced expiratory volume in 1 second (FEV1), forced vital capacity (FVC), and FEV1/FVC ratio [8, 9]. In Nigeria, biomass fuel use is widespread, particularly among occupational groups such as commercial food vendors, who rely on open-fire cooking with wood or charcoal for extended periods daily [10].

Previous studies in Nigeria have documented reduced lung function among biomass-exposed populations, such as fish smokers and charcoal workers. For instance, Umoh *et al*., reported significant reductions in FEV1 and FVC among fish smokers in the Niger Delta compared to controls ($p<0.001$) [13,11], while Nathan *et al*., found similar declines in food grillers (FEV1: 2.8 ± 0.5 L vs. 3.2 ± 0.5 L, $p<0.001$) [12]. Several other comparable studies in Nigeria have also demonstrated significant decline in lung function among persons chronically exposed to biomass smoke [13-16].

The duration of exposure to biomass smoke is a critical determinant of respiratory health, with longer exposure periods associated with progressive lung function decline and increased risk of ventilatory defects. Studies globally, such as Balcan *et al*., in Turkey, have demonstrated dose-response relationships between years of biomass exposure and reductions in FEV1 and FEV1/FVC ($r=-0.62$ to -0.81, $p<0.001$) [17]. In Nigeria, limited research has explored this relationship among occupational groups. Umoh *et al*., noted stronger negative correlations between exposure duration and lung function in fish smokers [11]. Similar findings were also observed in Nigeria by Oloyede *et al*., [13].

All the Nigerian studies quoted above were carried out in the Southern part of the Country. The only comparable study done in Northern Nigeria was by Adewole *et al*., in Katsina State, Northwestern Nigeria, in which they observed the FEV_1 to be significantly lower among meat grillers exposed to biomass smoke (2.62L) compared to the controls (3.09L) [18].

Despite the global and regional evidence linking biomass smoke to respiratory impairment, the specific impact on commercial food vendors in Northeastern Nigeria remains underexplored. This gap is significant, given the occupational prevalence of biofuel use and the potential for environmental factors to exacerbate health risks in this region. This study aims to evaluate ventilatory function parameters (PEF, FEV1, FVC, FEV1/FVC) and characterize ventilatory defect patterns (obstructive and restrictive) among commercial food vendors exposed to biofuel smoke compared to controls, and to assess the relationship between exposure duration and lung function impairment, using the Global Lung Initiative (GLI) Lower Limit of Normal (LLN) criteria. By addressing these objectives, the study seeks to inform occupational health interventions to mitigate respiratory risks in this vulnerable population.

MATERIALS AND METHODS

Study Design and Setting: This community-based cross-sectional study with a comparative design was conducted in Maiduguri, Borno State, Northeast Nigeria (11°51'N, 13°5'E), a city in the Sahel region with a subtropical steppe climate (average temperature: 27.4°C; rainy season: June–September). The study compared commercial food vendors exposed to biomass fuels (firewood/charcoal) with age-, sex-, and height-matched controls.

Study Population: The study population included food vendors in Maiduguri who fry, roast, or smoke local delicacies (e.g., bean cakes, fish, suya, yam) using biomass fuels in open or partially enclosed settings. Controls were Maiduguri residents without occupational exposure to biomass smoke or other respiratory hazards

Inclusion Criteria (Vendors):

- Aged >18 years, consenting to participate.
- Primarily using biomass fuels (wood/charcoal) for cooking.
- Worked as a food vendor for ≥1 year, ≥5 days per week.
- No prior diagnosis of chronic respiratory conditions (e.g., asthma, COPD).

Inclusion Criteria (Controls):

- Aged >18 years, consenting to participate.
- No history of work as food vendors or exposure to biomass smoke/dust/fumes.
- No prior diagnosis of chronic respiratory conditions.
- Resident in Maiduguri.

Exclusion Criteria (Both Groups):

- Aged <18 years or refusal to consent.
- Diagnosed chronic respiratory diseases (e.g., asthma, COPD, tuberculosis).
- Use of medications affecting lung function (e.g., steroids, methotrexate).
- Non-residents of Maiduguri (vendors); chest wall abnormalities (controls).
- Known contraindications for spirometry

Sample Size Determination

This study was done as part of a general study to assess the prevalence of respiratory symptoms and ventilatory function among vendors exposed to biofuels.

The sample size was calculated using Fisher's formula:
$n = z^2pq/d^2$
where (n) = sample size, z = 1.96 (95% confidence level), p = 0.867 (prevalence of respiratory symptoms from Akani *et al*.,),[19] q = 1 - p = 0.133, and d = 0.05

(margin of error). This yielded: $(1.96)^2(0.867)(1-0.867)/(0.05)^2 = 177$

With 10% attrition, the sample size was rounded to 195 vendors and 195 controls making a total of 390 across both arms of the study.

Multi stage sampling was used to recruit 195 consenting vendors and an equal number of age, sex, height and weight matched consenting controls from the 15 wards of Maiduguri. Questionnaires were administered to capture their sociodemographic characteristics and duration of exposure, followed by anthropometric measurements. A separate time was arranged for spirometry. However, twenty three (23) participants declined spirometric examination. This study therefore assesses the lung function of 367 consenting participants (182 vendors and 185 controls) across the 2 arms of the study.

Data Collection

Spirometry:

Ventilatory function was assessed using a portable battery-powered SP 100 spirometer (manufactured by Contec® Medical Systems Co., Ltd, China) following American Thoracic Society (ERS/ATS) guidelines.[20] Parameters measured included peak expiratory flow (PEF), forced expiratory volume in 1 second (FEV_1), forced vital capacity (FVC), and FEV_1/FVC ratio. Spirometry was performed between 8:00 AM and 2:00 PM to minimize diurnal variation. Obstructive ventilatory defects were defined as $FEV_1/FVC < LLN$, and restrictive defects as $FVC < LLN$ with $FEV_1/FVC \geq LLN$ [21].

Exposure Duration:

Duration of biofuel smoke exposure was assessed using a structured, interviewer-administered questionnaire. Vendors were asked about the number of years engaged in commercial food vending with biofuel use, hours worked per day, days per week, and months per year. Exposure duration was calculated as the total years of occupational exposure, verified through follow-up questions to minimize recall bias.

Anthropometric Measurements:

Height (cm) and weight (kg) were measured using a standard meter rule and a calibrated weighing scale, respectively, with participants barefoot and in light clothing based on WHO guidelines [22]. Measurements were taken twice, and the average was recorded to ensure accuracy.

Quality Control:

The spirometer was calibrated daily, and all measurements adhered to ATS acceptability and reproducibility criteria (e.g., no cough, early termination, or leaks; ≤150 mL variation between the best two FVC and FEV_1 values). Questionnaires were pre-tested on 20 participants (not included in the final sample) to ensure clarity and reliability. Research assistants were trained to standardize data collection, and all the spirometry was performed and interpreted by the principal researcher.

Statistical Analysis

Continuous variables (PEF, FEV_1, FVC, FEV_1/FVC, exposure duration) were summarized as means ± standard deviations (SD) or medians (interquartile range, IQR) if non-normally distributed, and compared between vendors and controls using independent t-tests or Mann-Whitney U tests. Categorical variables (ventilatory defect patterns: normal, obstructive, restrictive) were analyzed using chi-square tests. Pearson's correlation coefficient (r) was used to assess the relationship between exposure duration and ventilatory function parameters among vendors. Statistical significance was set at $p<0.05$. All analyses were performed using SPSS version 25 (IBM Corporation, Armonk, NY, USA)

Ethical Considerations

The study was approved by the Borno State Government Ethics Committee. Written informed consent was obtained from all participants after explaining the study's purpose, procedures, risks, and benefits in English or local languages (Hausa, Kanuri). Confidentiality was maintained by assigning unique identifiers to participants, and data were stored securely on password-protected devices.

RESULTS

Table 1 and Figure 1 show a summary of the sociodemographic characteristics of the participants. The means and standard deviation of the ages of the subjects and controls were 37.13±10.60 years and 36.51±10.13 years, respectively, with a mean difference of 0.62 year. The p value was 0.310, indicating no statistically significant differences between the two mean ages. The most common age group for both the subjects and controls was the 35-44 years group. There was no significant difference in the age distribution (p=0.357).

Table 1: Sociodemographic characteristics

Variable		Vendors N (%)	Controls N (%)	Total	X^2	P Value
Age (years)	(Mean ±SD)	37.13±10.6	36.51±10.13			0.310
	Mean difference	0.62	0.62			
	Age group					
	18-24	20 (11.1)	22 (11.9)	44 (11.8)	5.488	0.357

	25-34	52 (28.6)	62 (33.5)	115 (30.8)		
	35-44	61 (33.5)	68 (36.8)	129 (34.9)		
	45-54	41 (22.5)	26 (14.1)	67 (18.2)		
	55-64	5 (2.6)	5 (2.6)	10 (3.1)		
	>65	3 (1.7)	2 (1.1)	5 (1.3)		
	Total	**182 (100.0)**	**185 (100.0)**	**367 (100.0)**		
Marital status						
Female	Married	37 (39.8)	53 (58.9)		37.06	**<0.001**
	Divorced	31 (33.3)	4 (4.4)			
	Single	23 (24.7)	28 (31.1)			
	Widow	2 (2.2)	5 (5.6)			
	Total	**93 (100.0)**	**90 (100.0)**			
Male	Married	66 (74.2)	52 (54.7)		8.41	**<0.016**
	Divorced	2 (2.2)	1 (1.1)			
	Single	21 (23.6)	42 (44.2)			
	Total	**89 (100.0)**	**95 (100.0)**			
Education						
Female	Primary	14 (15.1)	1 (1.1)			**<0.001**
	Secondary	26 (27.9)	41 (45.6)			
	Tertiary	9 (9.7)	48 (53.3)			
	Quranic	44 (47.3)	0 (0)			
	Total	**93 (100)**	**90 (100)**			
Male	Primary	30 (33.7)	40 (42.1)			**0.387**
	Secondary	30 (33.7)	26 (27.4)			
	Tertiary	11 (12.4)	8 (8.4)			
	Quranic	18 (20.2)	21 (22.1)			
	Total	**89 (100)**	**95 (100)**			

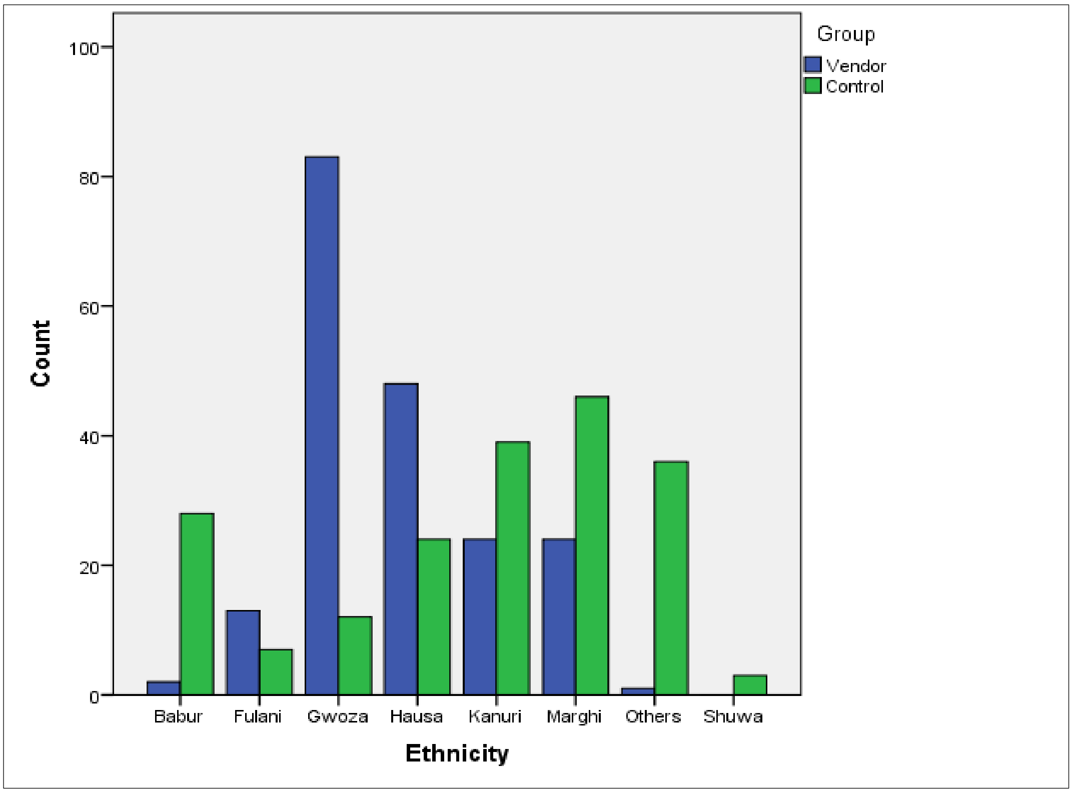

Figure 1: Ethnicity of participants

Table 2 shows a comparative analysis of the anthropometric measurements between the vendors and the controls.

Table 2: Anthropometric measurements of participants

Weight (Kg)			
Group	**Mean ± SD**	**Mean difference**	**P value**
Vendor (n=182)	62.31±11.91	0.63	0.571
Control (n=185)	61.68±10.06		
Height (m)			
Group	**Mean ± SD**	**Mean difference**	**P value**
Vendor (n=182)	1.64±0.09	-0.04	**<0.001**
Control (n=185)	1.68±0.08		
BMI (Kg/m^2)			
Group	**Mean ± SD**	**Mean difference**	**P value**
Vendor (n=182)	23.27±3.91	1.52	**0.022**
Control (n=185)	21.74±3.06		

Table 3 presents a comparative analysis of ventilatory function parameters between the subjects and the controls. The table reveals a consistent pattern of lower respiratory function in the subject group compared to the control group across all measured parameters.

Table 3: Absolute values of ventilatory function parameters

Ventilatory Function	Group (Mean ± SD)		P-value	Mean diff	CI of mean diff
	Vendor(N=182)	Control (N=185)			
PEF (1/s)	5.95 ± 1.170	6.49 ± 1.12	<0.001	-0.54	-0.79 to -0.31
FEV_1 (1)	2.36 ± 0.48	2.65 ± 0.42	<0.001	-0.27	-0.36 to -0.17
FVC (1)	3.10 ± 0.49	3.39 ± 0.54	<0.001	-0.29	-0.40 to -0.17
FEV_1/FVC (%)	76.72 ± 5.44	78.30 ± 4.26	0.002	-1.57	-2.58 to -0.57

Table 4 shows patterns of ventilatory defects across both arms of the study. The subjects showed a higher prevalence of both obstructive and restrictive ventilatory defects compared to the control group. The percentage of obstructive patterns is nearly twice as high in vendors (8.2%) as in controls (4.3%). Similarly, restrictive patterns are more common in subjects (1.6%) than in controls (0.5%). While there are observable differences in the distribution of ventilatory patterns between vendors and controls, these differences do not reach statistical significance (p=0.171).

Table 4: Comparison of patterns of ventilatory defect between vendors and controls

	Vendor n (%)	Control n (%)	P-value
Normal	164 (90.1)	176 (95.1)	0.171
Obstructive	15 (8.2)	8 (4.3)	0.13
Restrictive	3 (1.6)	1 (0.5)	0.34
Mixed	0 (0.0)	0 (0.0)	
Total	**182 (100.0)**	**185 (100.0)**	

Relationship Between Duration of Exposure to Biofuels and Ventilatory Function

Table 5 presents an analysis of the relationship between the duration of exposure to biofuel smoke and various ventilatory function parameters among a group of 182 vendors. The result shows only FEV1/FVC ratio shows a statistically significant negative correlation with the exposure duration (r=-0.230, p=0.002).

Table 5: Relationship between Duration of Exposure to Biofuel Smoke and Ventilatory Functions among Vendors

Ventilatory Functions (N=182)	Correlation*	P-value
PEF	-0.105	0.157
FEV1	-0.064	0.389
FVC	0.013	0.861
FEV1/FVC	-0.230**	0.002

**, Pearson Correlationsss*

***, Correlation is significant at the 0.01 level (2-tailed)*

DISCUSSION

The majority of the participants were between 25-44 years of age, accounting for 65.7% of the total population of study. The mean age of the vendors was 37.18±10.7 years, compared to the controls of 36.42±10.11 years which showed no statistically significant differences (p=0.303). Vendors averaged

1.64m in height, while controls averaged 1.68m, yielding a 0.04m (4cm) overall mean difference which falls within the 5cm matching criterion.

Ventilatory Function

The results of this study provide compelling evidence of significant differences in ventilatory function between street vendors and control subjects, with vendors consistently demonstrating poorer lung function across multiple parameters. This is consistent with findings from similar studies, such as the work by Ofori *et al.*, [23]. Nathan *et al.*, [12], and Ibhazehiebo *et al.*, [24], all in Nigeria. Similar findings were also recorded in Ethiopia [25]. Mexico [26], and Turkey [17].

The vendors consistently demonstrated statistically significant lower values of PEF, FEV_1, FVC, and FEV_1/FVC ratio. Vendors had a mean PEF of 5.95 L/s (± 1.170) compared to 6.49 L/s (± 1.12) in controls, a mean FEV_1 of 2.39 L (± 0.49) versus 2.65 L (± 0.49) in controls, and a mean FVC of 3.10 L (± 0.49) compared to 3.39 L (± 0.54) in controls. The mean FEV_1/FVC ratio was lower in vendors at 76.72% (± 5.44) compared to 78.30% (± 4.26) in controls. These differences were highly significant for PEF, FEV_1, and FVC ($p < 0.001$), and significant for the FEV_1/FVC ratio ($p = 0.002$).

The finding in the mean value of PEF is similar to findings observed by Dienye *et al.*, [27], in a similar study in Nigeria. They recorded a significantly lower mean PEF value of 5.35l/s (±0.98) among women who smoke fish in a rural setting in South-South Nigeria, compared to controls.[27] Ofori *et al.*, in the Niger Delta region of Nigeria also compared the PEF values in a cross-sectional study involving 321 non-smoking women and categorised them into biomass fuel users, kerosene users and LPG users. Biomass users had significantly lower mean PEF values (5.88±1.74), compared to kerosene users (6.27±1.17) and LPG (6.56±1.56) (p=0.005) [23]. A comparable study conducted in South-South Nigeria by Nathan *et al.* yielded results that align closely with the findings in this study. Their research focused on food grillers exposed to biofuels and examined their spirometry indices. The mean lung function values for food-grillers compared to fruit sellers were: FEV_1=2.8±0.5L vs 3.2±0.5, FVC=3.6±0.6L vs 3.9±0.8, FEV_1/FVC=78.5±4.9 vs 85.3 ±5.3; PEF=5.7± 1.2L/s vs 6.9 ±2.9 (p=<0.001). Just as in this study, they revealed a consistent pattern of significantly diminished lung function across all measured parameters [12].

The findings in this study also aligns with a study conducted by Obaseki *et al.*, in Ile Ife, Southern Nigeria which found that women who firewood for cooking demonstrated notably lower values of PEF, FEV_1, FVC and FEV_1/FVC ratio (p<0.001) compared to those using LPG [15]. Umoh *et al.*, also demonstrated similar results in a cross-sectional study assessing the relationship between lung function and indoor air pollution among rural women in the Niger Delta region of Nigeria. They demonstrated a significant reduction in both the absolute values of the measured ventilatory parameters as well as the percentages of their predicted values, all having p values of <0.001 [11].

However, the results from the study by Adewole *et al.*, in slightly deferred from this study in that not all lung function parameters were reduced in the subjects in comparison to the controls. Only FEV1 (2.50±0.55 versus 3.02±0.51, p=0.007) and FVC (2.7±0.7 versus 3.16±0.51, p=0.004) were significantly reduced [18].

The results of this study show some differences when compared to research conducted in Ethiopia. The Ethiopian study focused on women using biofuels for cooking and found significant differences in only two lung function parameters when compared to controls. Specifically, they observed statistically significant differences in FVC and FEV_1, with p-values of 0.03 and 0.017 respectively [25]. This contrasts with our findings, which demonstrated significant differences across a broader range of lung function parameters.

While the majority of research has shown a decline in lung function parameters among individuals exposed to biofuels, the findings are not entirely uniform across all studies. Some investigations have failed to detect statistically significant differences in these parameters when comparing exposed individuals to control groups [28]. Even more intriguingly, a small number of studies have reported an unexpected increase in certain lung function parameters among those exposed to biofuels compared to their unexposed counterparts. For instance, in a cross sectional study with a comparative design conducted in Sapele, Southern Nigeria Obiebi *et al.*, demonstrated higher values of s FEV1/FVC ratio and PEF among charcoal workers with mean differences of 5.68 (3.59–8.82)% and 0.31 (-23.70 to 24.43) L/min, respectively; but the mean difference was significant only for the FEV1 /FVC ratio [29].

These varied outcomes highlight the complexity of the relationship between biofuel exposure and respiratory function, suggesting that other factors such as individual susceptibility may play important roles in determining the ultimate impact on lung health. Again, it may be difficult to determine the actual exposure of the participants in these studies to biofuels.

This study identified two distinct patterns of ventilatory defects among participants: obstructive and restrictive. No mixed patterns (combining both obstructive and restrictive characteristics) were observed. While the vendor group showed a higher prevalence of ventilatory defects compared to the control group, the difference did not reach statistical significance. Specifically, 15 (8.2%) vendors exhibited obstructive defects, in contrast to 8 (4.3%) for the controls. Restrictive defects were observed in 3 vendors (1.6%) and of 1 control (0.5%). Despite these apparent differences, statistical analysis yielded a p-value of 0.13 and 0.34, for the obstructive and restrictive defects, respectively. Although the differences in obstructive and restrictive defects between vendors and controls were not statistically significant, they may be clinically significant. The near-doubling of obstructive defects among vendors and the threefold higher prevalence of restrictive defects may indicate a potential occupational exposure risks. The number of vendors who recorded normal ratio was 164 (90.1%) compared to 176 (95%) in the control group (p=0.171).

This finding is similar to those of Obaseki *et al*., in a cross-sectional study comparing respiratory symptoms and lung function between fire wood, kerosine and LPG users. They found 17.1% of fire wood users to have an obstructive pattern of ventilatory defect, compared to none among LPG users. 11.4% of fire wood users had a restrictive defect, compared to 4.7% in LPG users. Both were not statistically significant, as was the finding in this study. However, while this study used LLN of the ratio of FEV1/FVC to define normal, obstructive and restrictive defects, they used the absolute value of the ratio instead [30].

Similar findings were also observed in a Cameroonian study examining respiratory symptoms and lung function between solid fuel users and non- solid fuel users. It found the prevalence of airway obstruction to be 1.6% in the wood users compared to 0% in the controls, but without any statistically significant difference (p=0.21). However, the same study recorded a significant increase in prevalence of restrictive defect in wood users (9%) compared to controls (3%) with a p value of 0.004 [31]. Much higher prevalences for obstructive (21.6%) and restrictive (17.6%) were observed by Balcan *et al*., [17], among 424 women exposed to biomass in a small province in Eastern Turkey.

The observed variations in reported prevalence rates of ventilatory defects across studies may be partially explained by the differing diagnostic criteria employed - the use of the lower limit of normal (LLN) versus the fixed FEV1/FVC ratio (<0.7). For instance, the reported substantially higher prevalences of airway obstruction compared to this study by Obaseki and Balcan, may be partly attributed to their utilization of the fixed ratio method, which is known to potentially overestimate obstruction.

The FEV_1/FVC ratio demonstrated a weak negative correlation (-0.230) with exposure duration (p=0.002). The correlations for most parameters are negative, suggesting a trend towards decreased lung function with increased exposure duration, although most of these correlations were not statistically significant.

The negative correlations were more obvious in a study by Umoh *et al*., in a cross-sectional study in among rural women in Southern Nigeria, examining the relationship between lung function and in-door air pollution from biofuels. The study found significant negative correlation between the absolute values of PEF, FEV1, FVC and FEV1/FVC ratio (all p values of <0.001) [11].

A more negative correlation was established in an Indian study assessing the impact of biomass smoke from traditional on lung function in adult women in rural setting involving 310 women. They recorded a significant negative correlation between the duration of exposure and the percentages of the predicted values of FEV1, FVC and FEV1/FVC (all p=<0.001) [32]. Similar findings were also reported in a Brazilian study [33].

In contrast to the finding in this study, another cross-sectional study done in Mexico to assess the effect of biomass on respiratory symptoms and lung function, Regelado *et al*., concluded that increase in the duration of exposure to biomass was not associated with a decline in lung function in their study [26].

The observed variations in the correlation between duration of exposure and ventilatory function may be as a result of the different sample sizes in the studies and the possibility of recall bias.

CONCLUSION

This study demonstrates that chronic exposure to biofuel smoke significantly impairs ventilatory function among commercial food vendors in Maiduguri, Northeast Nigeria, as evidenced by reduced PEF, FEV1, FVC, and FEV1/FVC ratios. The difference in prevalence of ventilatory defects between the vendors and controls may suggest a potential occupational exposure risk. A negative correlation between exposure duration and FEV1/FVC suggests that prolonged exposure exacerbates airflow limitation. These findings underscore the need for targeted occupational health interventions, including improved ventilation, alternative fuel adoption, and regular respiratory health screenings, to mitigate the respiratory risks faced by this vulnerable population in Nigeria.

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