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Original Research Article

Respiratory Symptoms among Commercial Food Vendors Exposed to Biofuels Smoke in Maiduguri, Northeast Nigeria

Abdullahi O. Amali[1,2]*, Umar Loskurima[3], Jamila Audu Idrisa[1,4], Hadiza Umar Muktar[2], Ahmed Hammangabdo[1,2], Abdul Fattah Hassan Alhaji[1,5], Musa Dungus Musa[6], Adamu Abba[7], Mustapha Lawan[1,3], Mustapha Muhammad[7], Zakiyyah Zakariyya[8], Ijuptil Chiroma[1,5], Bukar Bakki[1,2]

[1]Department of Medicine, Department of Medicine, University of Maiduguri
[2]Division of Pulmonology, Department of Internal Medicine, University of Maiduguri Teaching Hospital
[3]Division of Nephrology, Department of Internal Medicine, University of Maiduguri Teaching Hospital
[4]Division of Dermatology, Department of Internal Medicine, University of Maiduguri Teaching Hospital
[5]Division of Endocrinology, Department of Internal Medicine, University of Maiduguri Teaching Hospital
[6]Department of Chemical Pathology, University of Maiduguri Teaching Hospital
[7]Division of Infectious Diseases, Department of Internal Medicine, University of Maiduguri Teaching Hospital
[8]Division of Cardiology, Department of Internal Medicine, University of Maiduguri Teaching Hospital

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Abstract: ***Background*:** Biomass fuel combustion, a common practice among commercial food vendors in Nigeria, generates harmful air pollutants that may increase respiratory symptoms. This study assesses the prevalence of respiratory symptoms among food vendors exposed to biomass fuels in Maiduguri, Northeast Nigeria, compared to unexposed controls. ***Methods*:** A community-based cross-sectional study with a comparative design was conducted among 195 food vendors using biomass fuels and 195 age-, sex-, and height-matched controls in Maiduguri. Respiratory symptoms were assessed using the Modified Medical Research Council (MRC) Questionnaire. Data were collected and symptom prevalence was compared using chi-square tests, with significance set at $p < 0.05$. ***Results*:** Vendors exhibited significantly higher prevalence of dyspnea (54.4% vs. 14.9%, $p < 0.001$), cough (18.5% vs. 9.7%, $p = 0.013$), and phlegm (13.8% vs. 6.2%, $p = 0.011$) compared to controls. Other symptoms, including wheeze (5.1% vs. 3.1%, $p = 0.305$), nasal congestion (8.7% vs. 6.7%, $p = 0.458$), runny nose (11.8% vs. 8.2%, $p = 0.234$), itchy nose (5.1% vs. 4.6%, $p = 0.354$), and sneezing (7.7% vs. 4.1%, $p = 0.192$), were more frequent among vendors but not statistically significant. ***Conclusion*:** Food vendors exposed to biomass fuels in Maiduguri experience a significantly higher prevalence of respiratory symptoms, particularly dyspnea, cough, and phlegm, compared to controls.

Keywords: Biomass Fuel, Respiratory Symptoms, Food Vendors.

INTRODUCTION

Commercial food vending is common in Nigeria just like in other African Countries [1]. Food vendors, comprising both males and females including those roasting meat (locally known as "Mai suya") or frying local delicacies such as bean cakes, plantain, yam, and grasshoppers, predominantly rely on biofuels such as firewood and charcoal for cooking [2]. These open-fire cooking practices, often conducted in roadside stalls or within communities, expose vendors to biomass smoke containing harmful pollutants, including particulate matter (PM2.5 and PM10), carbon monoxide (CO), carbon dioxide (CO2), nitrogen oxides (NO_2), and volatile organic compounds (VOCs) [3]. The main pollutant responsible for respiratory symptoms are the particulate matter (PM), which is made up of particles that can penetrate deep into the lungs and cause respiratory problems, with the most harmful forms of particulate matter being PM_{10} (<10µm), fine particles $PM_{2.5}$ (<2.5µm) and ultrafine particles (<0.1µm) [4, 5]. Exposure to biomass smoke is a major public health concern globally, particularly in low- and middle-income countries where biofuel use is prevalent (WHO, 2020). The World Health Organization (WHO) estimates that household air pollution from biomass fuel combustion contributes to approximately 3.8 million premature deaths annually, with a substantial burden in sub-Saharan Africa (WHO, 2020). In Nigeria, where over 70% of households rely on solid fuels for cooking, the respiratory health impacts are profound, especially for

***Corresponding Author:** Abdullahi O. Amali
Department of Medicine, Department of Medicine, University of Maiduguri

occupational groups like food vendors who face prolonged exposure to biomass smoke (National Bureau of Statistics, 2019). Sustained exposure to these particles therefore increases their chances of developing respiratory diseases [6-9]. Chronic inhalation of these pollutants is associated with respiratory symptoms such as dyspnea [10], cough [11], phlegm [12], wheezing [13], chest tightness [14], and nasal irritation [8].

The mechanisms driving these health effects are complex. PM2.5 deposits in the alveoli, triggering inflammatory responses mediated by alveolar macrophages and bronchial epithelial cells [15-16], leading to the release of pro-inflammatory cytokines such as interleukin-6 (IL-6), interleukin-8 (IL-8), and tumour necrosis factor-alpha (TNF-α). This chronic inflammation contributes to airway remodelling, fibrosis, and irreversible airflow obstruction, characteristic of COPD [17, 18], Additionally, polycyclic aromatic hydrocarbons (PAHs) in biomass smoke, such as benzo[a]pyrene (BaP), are carcinogenic, inducing DNA adducts and epigenetic changes that increase lung cancer risk [19]. Biomass smoke also impairs immune defences, reducing macrophage function and increasing susceptibility to respiratory infections like pneumonia, as evidenced by studies showing enhanced pathogen survival in exposed hosts [20-22].

In Nigeria, regional studies have highlighted the respiratory toll of biomass smoke exposure. Research in the Niger Delta conducted by Dienye *et al*., in 2011 found that fish smokers had a significantly higher prevalence of respiratory symptoms such as sneezing, catarrh and chest pain, compared to controls with cough having the highest prevalence of 65.71%.[6] Similarly, Adewole *et al*., in a study in Kebbi State reported chest tightness as the dominant symptom among meat roasters, with a prevalence of 59% [14]. Obaseki *et al.,* in a population study in Ile Ife, Southern Nigeria found that the use of biomass as domestic fuel is associated with cough and lower quality of life. The research, which followed the Burden of Obstructive Lung Diseases (BOLD) study protocol, assessed the relation of biomass-exposed individuals, particularly women, were more likely to have cough and lower quality of life [11].

Similar studies in North Central Nigeria [23], and Southern Nigeria [24-26], have also demonstrated increased prevalence of respiratory symptoms in individuals chronically exposed to biomass smoke compared to controls. Regional [27, 28], and international [8-30], studies have also recorded similar findings.

However, there is a notable research gap in Northeast Nigeria. This study is therefore justified by the need to generate local prevalence of respiratory symptoms and lung function abnormalities among commercial food vendors in Maiduguri. Furthermore, understanding the respiratory health impacts in this population is important for informing intervention strategies to reduce risk and help guide policies and programs to protect lung health in the target population.

METHODOLOGY

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).

Sample Size Determination

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*.,) [6] 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.

Data Collection

Data were collected between February and May using multistage sampling (random selection of 15 wards and vending sites in Maiduguri). Participants provided written informed consent. Respiratory symptoms (dyspnoea, cough, phlegm, wheeze, nasal congestion, runny nose, itchy nose, sneezing) were assessed using the Modified Medical Research Council (MRC) Questionnaire.

Data Analysis

Symptom prevalence was analysed using frequency tables and chi-square tests to compare vendors and controls. Data were analysed using SPSS version 25 (IBM Corporation, USA), with statistical significance set at $p < 0.05$.

Ethical Considerations

Ethical approval was obtained from the Borno State Government, and informed consent was secured. Confidentiality was maintained throughout.

RESULTS

Table 1 and Figures 1–2 summarize the sociodemographic characteristics of participants.

The mean age of vendors was 37.18 ± 10.17 years, and controls were 36.42 ± 10.11 years, with a non-significant mean difference of 0.76 years ($p = 0.303$). The most common age group for both was 35–44 years.

Females showed significant differences ($p < 0.001$) showed vendors had higher divorce rates (33.7% vs. 5.1%) and lower marriage rates (39.8% vs. 58.2%) compared to controls.

Male vendors had higher marriage rates (73.2% vs. 54.6%) and lower single rates (24.7% vs. 44.3%) compared to controls.

Most female vendors had Quranic education, while 54.1% of controls had tertiary education, with a significant difference ($p < 0.001$).

Most males had primary or secondary education in both groups, with no significant difference ($p = 0.389$).

Female vendors were predominantly Marghi (24.5%), with significant Hausa, Gwoza, Kanuri, and Fulani representation; controls were more ethnically diverse. Male vendors were mostly Gwoza (62.9%) and Hausa (32.0%).

Table 1: Sociodemographic characteristics

Variable		Vendors N (%)	Controls N (%)	Total	X^2	P Value
Age (years)	(Mean ±SD)	37.18±10.7	36.42±10.11			0.303
	Mean difference	0.76	0.76			
	Age group					
	18-24	22 (11.3)	24 (12.3)	46 (11.8)	5.498	0.358
	25-34	55 (28.2)	65 (33.3)	120 (30.8)		
	35-44	65 (33.3)	71 (36.4)	136 (34.9)		
	45-54	44 (22.6)	27 (13.8)	71 (18.2)		
	55-64	6 (3.1)	6 (3.1)	12 (3.1)		
	>65	3 (1.5)	2 (1.0)	5 (1.3)		
	Total	**195 (100.0)**	**195 (100.0)**	**390 (100.0)**		
Marital status						
Female	Married	39 (39.8)	57 (58.2)		37.08	<0.001
	Divorced	33 (33.7)	5 (5.1)			
	Single	24 (24.5)	31 (31.6)			
	Widow	2 (2.0)	5 (5.1)			
	Total	**98 (100.0)**	**98 (100.0)**			
Male	Married	71 (73.2)	53 (54.6)		8.42	<0.015
	Divorced	2 (2.1)	1 (1)			
	Single	24 (24.7	43 (44.3)			
	Total	**97 (100.0)**	**97 (100.0)**			
Education						
Female	Primary	15 (15.3)	1 (1.0)			<0.001
	Secondary	28 (28.6)	44 (44.9)			
	Tertiary	9 (9.2)	53 (54.1)			

	Quranic	46 (46.9)	0 (0)			
	Total	**98 (100)**	**98 (100)**			
Male	Primary	32 (33.0)	42 (43.3)			0.389
	Secondary	33 (34.0)	26 (26.8)			
	Tertiary	12 (12.4)	8 (8.2)			
	Quranic	20 (20.6)	21 (21.6)			
	Total	**97 (100)**	**97 (100)**			

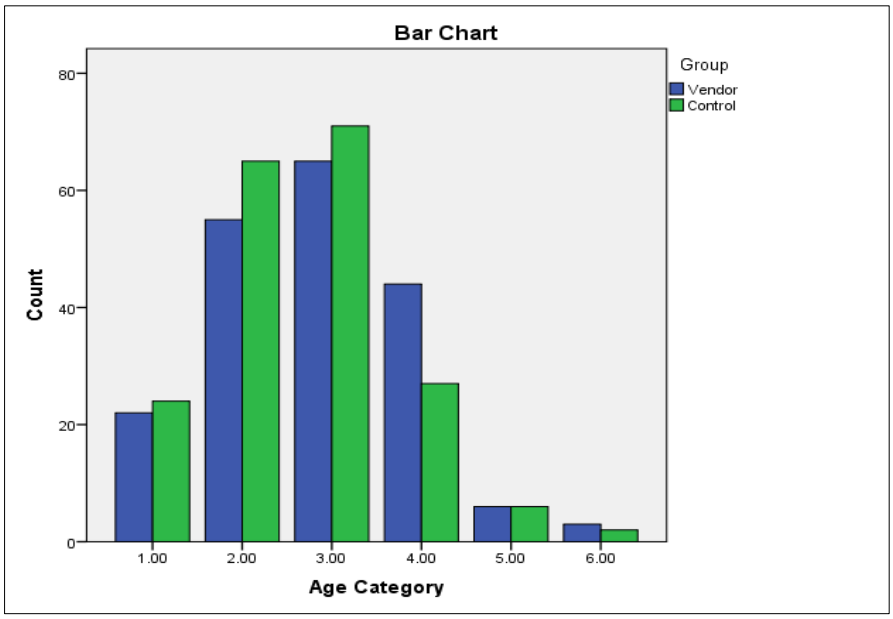

Figure 1: Age distribution

On the X-axis, age category
1.0 = 18 – 24 years
2.0 = 25 – 34 years
3.0 = 35 – 44 years
4.0 = 45 – 54 years
5.0 = 55 – 64 years
6.0 = 65 years and above

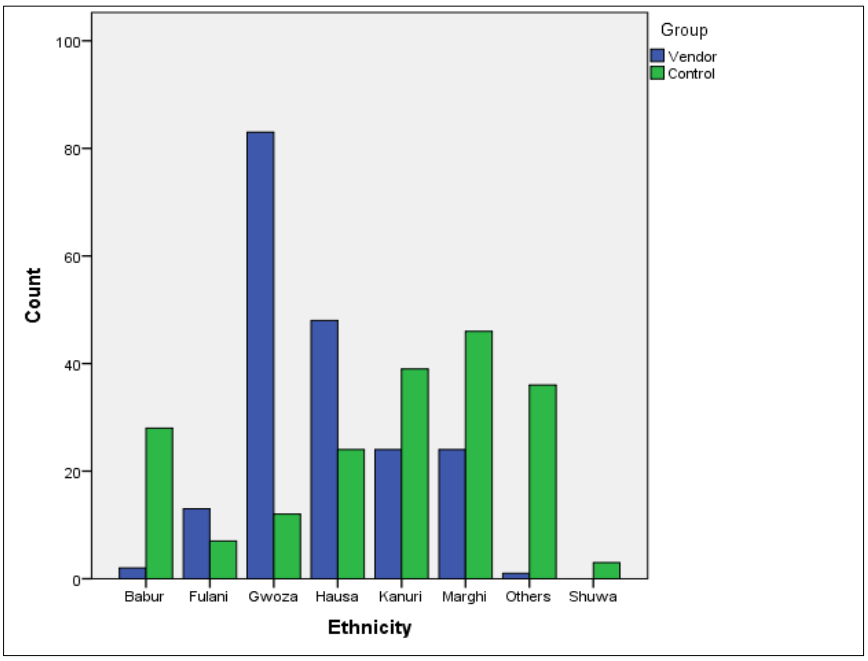

Figure 2: Ethnicity of participants

Table 2 compares the prevalences of respiratory symptoms between the subjects and controls. The prevalence of respiratory symptoms was higher in the study population compared to the controls, with dyspnoea having the highest prevalence (54.4% in vendors versus 14.9% in controls, p= <0.001), followed by cough (18.5% in vendors versus 9.7% in controls, p=0.013) and then phlegm (13.8% in vendors versus 6.2% in controls, p=0.011). The other respiratory symptoms of wheeze, runny nose, blocked nose, itchy nose and sneeze also had higher prevalences in the subjects, but were not statistically significant (p values of 0.305, 0.057, 0.182, 0.354 and 0.192 respectively).

Table 2: Prevalence of respiratory symptoms

	Vendors (N=195)	Controls (N=195)	P-value
Symptoms	**n (%)**	**n (%)**	
Dyspnoea	106 (54.4)	29 (14.9)	<0.001
Wheeze	10 (5.1)	6 (3.1)	0.305
Cough	36 (18.5)	19 (9.7)	0.013
Phlegm	27 (13.8)	12 (6.2)	0.011
Blocked Nose	17 (8.7)	13 (6.7)	0.182
Runny Nose	23 (11.8)	13 (6.7)	0.057
Itchy Nose	10 (5.1)	9 (4.6)	0.354
Sneeze	15 (7.7)	8 (4.1)	0.192

DISCUSSION

In this study, dyspnoea, cough, and phlegm emerged as the symptoms with statistical significance between vendors and controls.

Dyspnoea was the most prevalent respiratory symptom, reported by 54.1% of vendors compared to 14.9% of controls (p<0.001). Although numerous studies have demonstrated an increased prevalence of respiratory symptoms among individuals exposed to biofuels [10-31], none of these comparable studies demonstrated dyspnoea as the most prevalent symptom.

A cross-sectional study by Adewole *et al*., in Kebbi State, Nigeria, reported a high prevalence of respiratory symptoms among individuals exposed to biomass, with chest tightness being the most common symptom (59%) and dyspnea at 18.9% [14]. In contrast, this study, with a larger sample size (390 against 160), found dyspnoea as the predominant symptom (54.4%). Both studies used the modified MRC questionnaire, potentially introducing recall bias. The Kebbi study included only men, while the Maiduguri study had equal male and female participants, which may explain differences in symptom reporting due to varying thresholds between genders. The larger sample size in the Maiduguri study likely provided greater statistical power.

The prevalence of dyspnoea in this study is significantly higher than findings in a similar study by Dienye *et al*., [6], in a rural setting in Rivers State, Southern Nigeria, which recorded prevalence of dyspnoea to be 3.33%. A Southern Nigeria study by Obiebi *et al*., also found a much lower prevalence of dyspnoea (19.6%) among charcoal workers [13]. Both studies included males and females. The disparity may be due to climatic differences: Northern Nigeria's arid climate and frequent Sahara-derived dust storms increase respiratory irritants, while Southern Nigeria's high humidity may reduce airborne particulates. Recall bias, potentially affecting both studies due to unspecified respiratory questionnaires, may also contribute to the differences in dyspnoea prevalence. Ngahane *et al.,* [10], in semi-rural Cameroon also found dyspnoea to be present in 22.1% of women exposed to cooking fuel smoke.

Cough was found to be the second most prevalent and statistically significant symptom among subjects, with 18.5% reporting cough compared to 9.7% among controls (p=0.013). This significant difference aligns with patterns observed in similar studies worldwide, although most studies reported higher cough prevalence rates. For instance, a study in Southwest Nigeria by Obaseki *et al.,* found cough to be the most common symptom among adults using domestic solid fuels, with 57.1% reporting cough [24]. In a similar study in rural Rivers State of Nigeria Dienye *et al.,* examined the respiratory effects of biomass fuel combustion among 210 rural women who smoke fish and found cough to have a prevalence of 65.71% [32]. A prevalence of 32% was recorded by Adewole *et al*., [14], in Kebbi State, Northern Nigeria. Akani *et al.,* [6], in a community-based cross-sectional study examining respiratory symptoms among 270 women smoking fish in a rural community in Nigeria also reported higher cough prevalences of 28.57%. However, lower cough prevalences, compared to this study were noted by Obiebi [13]. (9.5%) and another study by Obaseki (11.4%) [33], both in Southern Nigeria. Again, all these studies were conducted in Southern Nigeria with weather and climate conditions very much different from what is obtained in Northern Nigeria, where this study was conducted. This may account for the difference in prevalences. While Southern Nigeria's high humidity may reduce airborne particulates, excessive humidity can potentially increase cough prevalence through promotion of mold/spore growth triggering allergic cough [34],

enhanced survival of respiratory pathogens in humid air (influenza, Respiratory Syncytial Virus)[35] and humidity-induced bronchoconstriction in some asthma phenotypes [36].

The prevalence of phlegm in the vendors in this study was found to be 13.8% compared to 6.2% in the controls (p=0.011). Similar findings were observed in Sri lanka, (16%) [12]. Ethiopia, (12.2%) [29], and India (18.15%) [37]. Much higher prevalences were recorded by Obaseki *et al*., (45.7%) [11], while lower prevalences were recorded in studies conducted by Akani in the Niger Delta region of Nigeria (7.62%) [6], and Obaseki in Southern Nigeria (8.5%) [38].

Wheeze, blocked nose (nasal congestion), runny nose, itchy nose and sneezing were more prevalent in the vendors compared to the controls but they were of no statistical significance.

Wheeze was present in 5.1% in the vendors compared to 3.1% in the controls (p=0.305). However, in a similar study done in North West Nigeria, wheeze was found to be significantly higher prevalence among the study group (12%) compared to the controls (0%) with a p value of 0.04.[14] Significantly increased prevalence of wheeze was also reported in Sri lanka [12], and Nigeria [13].

Nasal congestion and runny nose recorded prevalences of 8.7% and 11.8% respectively, with no significant differences with the controls. This is in contrast with the finding in a similar study done in Southern Nigeria among rural women who smoked fish with biofuels in which blocked nose (nasal congestion) and runny nose (both grouped under catarrh) had a prevalence of 75.71% [32].

Itchy nose had a prevalence of 5.1% in the vendors versus 4.6% in the controls (p=0.354). This symptom was difficult to correlate with other studies because it may have been grouped under symptoms of allergy.

Similarly, sneeze was also not significantly increased in the vendors when compared to the controls, with a prevalence of 7.7% and 4.1% in the vendors and controls respectively (p=0.192). This is in contrast to the prevalence of 73% in a study done among fish smokers in by Akani *et al*., [6], and Dienye *et al*., [32]. (72.86%), both in Southern Nigeria.

It is observed that there is a significantly higher prevalences of sneeze, nasal congestion and wheeze in the Southern Nigerian studies compared to this study. The only comparable study in Northern Nigeria by Adewole *et al*., [14], demonstrated higher prevalences of wheeze (12%) and nasal congestion (37%) than in this study. A possible explanation for this disparity may be the time of the year the studies were conducted. While this study took place between the months of February and May, the Kebbi study was done during the harmattan period, during which there is generally increased incidence of respiratory symptoms. Another factor may be the relatively smaller sample size, compared to this, which may reduce the statistical power of the study.

CONCLUSION

This study demonstrates that food vendors in Maiduguri, Northeast Nigeria, who are chronically exposed to biomass smoke experience significantly higher prevalence of respiratory symptoms. Dyspnoea, cough and phlegm were significantly more prevalent among the vendors, with dyspnea being the most prevalent symptom. These findings underscore the respiratory health risks associated with prolonged exposure to biomass in this occupational group. Given the substantial burden of respiratory symptoms observed, there is a pressing need for targeted interventions and policies to reduce exposure to biomass smoke among food vendors in this region. These measures will be critical to protecting lung health and improving quality of life for the vulnerable population.

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