RESEARCH ARTICLE

Knowledge, attitudes and beliefs about the health hazards of biomass smoke exposure amongst commercial food vendors in Nigeria

Ogonna N. O. Nwankwo[1]*, Ndubuisi Mokogwu[2], Orighomisan Agboghoroma[3], Fahmi O. Ahmed[4], Kevin Mortimer[5]

1 Department of Community Medicine, University of Calabar Teaching Hospital, Calabar, Nigeria, **2** Department of Community Health, University of Benin Teaching Hospital, Benin, Nigeria, **3** Department of Medicine, Jos University Teaching Hospital, Jos, Nigeria, **4** College Health Sciences, Addis Ababa University, Addis Ababa, Ethiopia, **5** Department of Clinical Sciences, Liverpool School of Tropical Medicine, Liverpool, United Kingdom

* drogonnanwankwo@gmail.com

Abstract

Background

Exposure to biomass smoke is a major cause of morbidity and mortality in Africa. Commercial food vendors in Nigeria and elsewhere in Africa are commonly exposed to biomass smoke from open fire cooking both at work and home. Little is known about the knowledge, attitudes and beliefs of food vendors about the health hazards of biomass smoke exposure in Nigeria.

Methods

We did a descriptive cross sectional survey of the knowledge, attitudes and beliefs of commercial food vendors in the cities of Benin and Calabar in Nigeria. We recruited respondents using a multi-stage approach. Structured interviewer-administered questionnaires were used for data collection.

Results

We recruited 308 participants (164, 53.2% female). The majority 185(60.2%) were married and had post-primary education 206(67.4%). The average monthly income was <30,000 Naira (US$150). Most 198(64.4%) were not aware that biomass smoke exposure is harmful to human health. About three-quarters (221; 71.8%) were unconcerned as to the effect of exposure to fumes from biomass fuels on their health. Less than half of respondents (110, 41.6%) believed biomass smoke was harmful to health. Male gender, being single, having post-primary education and preferring electricity or gas fuels were associated with good knowledge of the adverse health effects of biomass smoke exposure whilst female gender and having good knowledge of the adverse health effects of biomass smoke were associated with positive attitudes towards preventing exposure.

Conclusion

Commercial food vendors in our study had limited knowledge about the adverse health effects of biomass smoke exposure and negative attitudes towards preventing these adverse health effects. We suggest an educational intervention is needed to improve this knowledge.

Introduction

Approaching half of the World's population depend on biomass fuels (animal dung, crop residues, wood, charcoal) for their day-to-day fuel energy needs.[1] Biomass fuel use is a major cause of both indoor (household) and ambient (outdoor) air pollution with a socio-economic differential in its use. [2–4] It is now widely recognized that exposure to smoke from the burning of biomass fuels is a major cause of global morbidity and mortality from respiratory diseases and non-communicable diseases such as lung cancer, stroke, ischaemic heart diseases amongst others.[3–9] Pneumonia in children and chronic obstructive pulmonary disease (COPD) in adults have been most clearly associated with biomass smoke exposure.[7, 10–12] Dependence on biomass fuels is a problem of poverty with low-middle income country (LMIC) populations, especially the poorest of the poor, bearing a disproportionate burden of the attributable diseases. [8, 13] More than one third of the total burden of disease attributed to biomass smoke is seen in Africa. [14, 15]

Commercial food vending is a popular business activity in most cities in Africa. [16–18] Commercial food vendors typically cook street foods like bean cake, roasted plantain, bean pudding and local delicacies using biomass fuels burned in open fires. Commercial food vendors are often women who are often also the primary cooks at home and as such experience frequent biomass smoke exposure through these gender-based roles.[18–20] There is evidence from studies done in Nigeria and Cameroon that there is a higher prevalence of respiratory symptoms in commercial food vendors and cooks exposed to biomass smoke compared to those who are not exposed.[19, 21–23] Again, due to the nature of their work, they are exposed to other sources of air pollution such as vehicular emission, stationary power generating sets amongst others which further predisposes them to health hazards. [2, 4]

Behavioural and social medicine has postulated a number of theories in trying to explain and influence human actions, of which one of the most important is the social cognitive theory which offers possible explanation on the relationship between one's attitude and behaviour, with knowledge given a special importance due to its mediating role.[24–27] This theory amongst others forms the underpinning for the traditional knowledge–attitude–behavior models (KAB) or sometimes KAP model (referring to knowledge, attitude and practice) on changing actions.[28, 29] Various studies from health related issues have shown the important mediating role knowledge plays for environmental and health-related attitude, behavior and practise.[25, 30–35]

Improving knowledge about the harmful health effects of biomass smoke has been proposed as an important step towards modifying behavior to reduce exposure to biomass smoke and other forms of household air pollution.[36] A lack of knowledge about the link between exposure to biomass smoke and adverse health outcomes as well as acceptability and accessibility of clean energy has been found to be important barriers to the uptake of clean cooking technologies.[37, 38]

Little is known about levels of knowledge, attitudes and beliefs of food vendors about the adverse health effects of biomass smoke exposure in African countries like Nigeria. We set out

to fill this gap in the evidence by undertaking a cross-sectional survey of commercial food vendors in Benin and Calabar cities, Nigeria.

Materials and methods

Setting

Nigeria is located on the western coast of Africa and occupies approximately 923,768 square kilometres of land stretching from the Atlantic coast in the south to the fringes of the Sahara Desert in the north.[39] It is bounded by the republics of Niger and Chad in the north, the Republic of Cameroon on the east, and the Republic of Benin on the west. The country's last population and housing census in 2006 is placed at over 140 million which is projected to be 187,648,291 in 2017.[39, 40] The country has a tropical climate with wet and dry seasons and has varying vegetation ranging from mangrove swamp forest in the south to Sahel grassland in the north. It has over 100 ethnic groups with Igbo, Yoruba and Hausa-Fulani groups being the commonest ones. Nigeria runs a democratic system of government and is made up of 36 states with the federal capital territory located in Abuja. Benin and Calabar cities are in 2 different states in the South-south geo-political zone of Nigeria. Both cities represent typically most big cities in Nigeria and their residents are mainly small- to medium-scale business owners, farmers, artisans, civil servants, bankers, and students. The country's gross national income per capita which reflects the average income of citizens of the country for the year as of 2016 is US $2450 while the poverty threshold level per individual is set at US$276 per annum. [40, 41]

Participants

A multi- stage sampling method was used to select the respondents. A single local government area (LGA) was initially selected from the LGAs that made up each city (3 LGAs made up Benin city while 2 LGAs made up Calabar city) by simple random sampling using balloting. Thereafter two wards were selected from a list of the wards that make up the selected LGAs (12 wards for Oredo LGA in Benin city and 10 wards for Calabar Municipality LGA in Calabar city) using simple random sampling technique. All commercial food vendors found in the streets making up the selected wards were eligible to participate. Out of 337 potential respondents found in the wards we sampled, 308 agreed to participate with most declining on account of the busyness of their schedule. Most of the respondents as stated in previous study operate mainly small to medium outlets with some cooking in enclosures and vending their meals ranging from fried or smoked fish and meat, roasted corn and pears, fried yam and potatoes, bean cake as well as local delicacies outside.[16, 20, 42]

Data collection

Data was collected between September and October 2015, using a structured interviewer-administered paper questionnaire partly based on the standardized American thoracic society-division of Lung disease (ATS-DLD) questionnaire and literature reviews.[43, 44]The survey instrument was reviewed by a group of academics, occupational health physicians, epidemiologists and public health physicians drawn from academic and health institutions from both cities as well as environmental health experts from Liverpool school of Tropical Medicine and found to have face validity. The reviews resulted in minor modification in the initially designed questionnaire. The questionnaire had 3 sections: 1) socio-demographic data including age, occupation, household size, income and marital status; 2) the respondents' knowledge about biomass smoke and associated health problems; 3) questions about attitudes and beliefs towards the adverse health effects of biomass smoke. The details of the specific questions that

were asked are in S1 File. A composite knowledge and attitude score was derived by applying a scoring system to questions pertaining to knowledge (Q15, Q17, Q18, Q20 and Q25) and attitudes (Q26, Q28, Q30, Q33 and Q34) in the questionnaire. One point was awarded for each correct answer and no point was awarded for an incorrect answer both for the single choice and multi-choice question types. Questions with Likert scale questions were ranked such that stronger agreement with positive answers had higher score with a one-point interval between each rank.

The questionnaire was pre-tested among 20 traders from neighbouring LGAs to our study sites to ensure comprehensibility, clarity of wording, and reliability of study tool. Three trained research assistants from each site, who had a minimum of university degree were trained to do the data collection.

Sample size

Sample size was calculated using a single proportion sample size formula assuming 14% of participants would have a given level of knowledge based on the findings of a previous study,[44] a precision of 5%, clustering factor of 1.5 and a 10% non-response rate. This gave a target sample of 300.

Statistical analysis

Questionnaire data were entered into the IBM statistical package for scientific solution (SPSS) version 20 statistical software (SPSS Inc, Chicago, IL, USA) in preparation for analysis. The primary outcome was a composite measure of the levels of the knowledge and attitudes about the adverse health effects of biomass smoke exposure. The composite scores calculated for each respondent was converted to percentages such that scores of less than 50% was categorized as poor knowledge or attitude while a score of 50% and above was categorized as good knowledge or attitude respectively. Categorical data were presented as frequency tables while inferential analysis was done at bivariate level with Chi-square test and at multivariate level with binary logistic regression. The level of statistical significance was set at $P < 0.05$.

Ethical considerations

The research ethics committees of the University of Benin Teaching Hospital and the University of Calabar Teaching Hospital, Nigeria approved the study. The protocol numbers were ADM/E 22/A/VOL. VII/1239 and UCTH/HREC/33/366. Written informed consent was obtained from all respondents. For respondents considered minors consent was obtained from their parents or guardians while assent was obtained from them.

Results

We interviewed 308 commercial food vendors, 106 (34.4%) from Benin City and 202 (65.6%) from Calabar. The mean (SD) age was 35.9 (10.8) years; 164 (53.2%) were women (Table 1). Half of the vendors (167; 54.2%) were educated to secondary level. A quarter (75; 24.4%) had worked at their present job for six to ten years. More than two thirds of the vendors (215; 69.8%) earned less than twenty thousand naira (100 US$) a month (US$1 = ₦200). The median (range) number of days spent working each week was 6 (0–7) and the median (range) amount of time spent cooking at work and at home per day was 3 (0–10) and 2 (0–8) hours, respectively.

Table 1. Food vendor characteristics.

Variable	n(%) n = 308
Age Group	
16–25	54(17.5)
26–35	108(35.1)
36–45	93(30.2)
46–55	36(11.7)
>55	17(5.5)
Sex	
Male	144(46.8)
Female	164(53.2)
Marital status	
Single	91(29.5)
Married	185(60.1)
Widowed	13(4.2)
Separated/divorced	13(4.2)
Co-habiting	6(1.9)
Level of education	
No formal	26(8.4)
Primary	76(24.7)
Secondary	167(54.2)
Tertiary	33(10.7)
Postgraduate	6(1.9)
Monthly income (₦)	
<10000	112(36.4)
10000–19999	103(33.4)
20000–29999	56(18.2)
30000–39999	19(6.2)
40000–49999	13(4.2)
50000 and above	5(1.6)
Duration in present job (years)	
0–5	208(67.5)
6–10	75(24.4)
11–15	13(4.2)
>15	12(3.9)
Fuel type used*	
Biomass fuel	182(63.0)
Kerosene	131(45.3)
Gas	26(9.0)
Electricity	2(0.7)

* Multiple responses

https://doi.org/10.1371/journal.pone.0191458.t001

Knowledge, attitudes and beliefs amongst the food vendors about the harmful effect of exposure to biomass fuel smoke

A third of vendors (110; 35.7%) reported being aware of the harmful effects of biomass smoke exposure; respiratory problems such as cough and catarrh were most commonly reported. An awareness of breathing problems in children exposed to biomass fuel smoke was reported by

107 (34.7%) participants. Methods reported by the respondents to mitigate the harmful effect of exposure to biomass fuel smoke included using a room with open doors and windows as a kitchen (147; 61.0%), use of a separate room for cooking (142; 58.9%), shielding the fire (127; 52.7%) and using a cleaner cooking fuel (63; 26.1%). A composite score of knowledge revealed that 169 (29.9%) vendors had good knowledge of the harmful effects of biomass smoke exposure.

Regarding attitudes, 87 (28.2%) vendors reported they would be concerned if informed that their current cooking fuel could adversely affect their health; the remainder (221; 71.8%) did not know, were indifferent or were unconcerned. Just under half (146; 47.4%) perceived their cooking fuel as safe for their health; 11 (3.65) and 102 (33.1%) perceived their cooking fuel as highly unsafe and unsafe to their health, respectively. One hundred and forty (45.5%) vendors agreed to potentially support a ban on the commercial use of cooking fuels that emit harmful levels of smoke if government was to embark on that. A composite score of attitudes revealed that 90 (29.2%) vendors had positive attitudes towards preventing the adverse health effects of biomass smoke exposure.

Regarding beliefs, 192 (62.3%) vendors believed that some forms of cooking fuel such as kerosene, electricity were less harmful to health than others. Liquid petroleum gas (LPG) was believed to be the least harmful by 123 (64.1%) of these vendors while biomass fuel was believed to be least harmful by only 7 (3.6%). Of the 180 vendors who gave a reason for their belief that LPG was least harmful, 84 (46.7%) said this was because LPG is smokeless. When asked about their preferred cooking fuel, kerosene was reported by 107 (34.7%), gas by 87 (28.2%) and biomass by 86 (27.9%) vendors. The reasons vendors chose biomass fuels were due to low cost (n = 66, 76.7%), fast cooking time (n = 65, 75.6%) and the better taste (n = 58, 67.4%).

Bivariate analysis of knowledge score against independent variables revealed that knowledge was significantly associated with male gender (p<0.001), a higher level of education (p<0.001), monthly income (p = 0.001), preferred cooking fuel source (p = 0.03) and duration spent in present job (p = 0.001) (Table 2).

Bivariate analysis of attitude composite score against independent variables revealed that positive attitudes to preventing adverse health effects of biomass smoke exposure were associated with older age (p = 0.048), female sex (p<0.01), being married (p = 0.012), higher monthly income (p<0.01) and having knowledge about the adverse health effects of biomass smoke exposure (p<0.01) (Table 3).

A logistic regression analysis to control for confounders and determine predictors of knowledge about the adverse health effects of biomass smoke exposure and attitudes towards preventing adverse health effects of biomass smoke exposure is shown in Table 4. The analysis revealed that being male, single, having post-primary education, having a preference for electricity or gas as a source of fuel and earning about 10,000 Naira (US$50) were significantly associated with higher levels of knowledge about the adverse health effects of biomass smoke exposure. Being female and having a high knowledge score were significantly associated with having a positive attitude towards preventing adverse health effects of biomass smoke exposure.

Discussion

The main findings of our cross-sectional study are that over half the Nigerian commercial food vendors we sampled were unaware of the adverse health effects of biomass smoke exposure, and an even greater proportion, about three-quarters, had poor attitudes towards preventing these adverse health effects and were unconcerned as to whether it is harmful to their

Table 2. Bivariate variables for knowledge of harmful effects of biomass fuel smoke.

Predictor variables	Knowledge n(%)		p value	OR (95% CI)
	Poor	Good		
Age group				
16–25	40(18.5)	14(15.2)	0.275	1
26–35	75(34.7)	33(35.8)		1.26(0.61–2.60)
36–45	68(31.5)	25(27.2)		1.05(0.49–2.24)
46–55	25(11.6)	11(12.0)		1.26(0.50–3.16)
>55	8(3.7)	9(9.8)		3.21(1.07–9.69
Sex				
Female	135(62.5)	29(31.5)	0.0001*	1
Male	81(37.5)	63(68.5)		0.28(0.16–0.46)
Marital status				
Ever married	155(71.8)	56(60.9)	0.062	1
Never married	61(28.2)	36(39.1)		0.61(0.37–1.02)
Level of education				
No formal	24(11.1)	2(2.2)	0.0001*	1
Primary	63(29.2)	13(14.1)		2.48(0.53–11.48)
Secondary	118(54.6)	49(53.3)		4.98(1.17–21.31)
Tertiary/PG	11(5.1)	28(30.4)		30.55(0.40–4.29)
Monthly income (₦)				
<10000	92(42.6)	20(21.7)	0.001*	1
10000–19999	69(31.9)	34(37.0)		2.27(1.21–4.26)
20000–29999	33(15.3)	23(25.0)		3.21(1.57–6.55)
30000–39999	8(3.7)	11(12.0)		6.32(2.31–17.34)
≥40000	14(6.5)	4(4.3)		1.31(0.40–4.29)
Preferred cook fuel				
Biomass	71(32.9)	15(16.3)	0.001*	1
Kerosene	81(37.5)	26(28.3)		1.52(0.75–3.08)
Gas	49(22.7)	38(41.3)		3.67(1.83–7.36)
Electricity	15(6.9)	13(14.1)		4.10(1.64–10.25)
Duration in present job				
0–5	150(69.4)	58(63.0)	0.032*	1
6–10	54(25.0)	21(22.8)		1.01(0.56–1.81)
11–15	8(3.7)	5(5.4)		1.62(0.53–4.93)
>15	4(1.9)	8(8.7)		5.17(1.58–16.97)

*Statistically significant at p<0.05 and the absence of the null value (1.00) from the CIs of the odds ratio.

health or not. This was despite the majority study participants believing that biomass smoke exposure is harmful.

We found that determinants of higher levels of knowledge about the adverse health effects of biomass smoke exposure were being male, single, having a post- primary level of education and having a preference for electricity or gas as a source of fuel whilst being female and having good knowledge about the harmful effects of biomass smoke were independently associated with positive attitudes towards preventing exposure.

Our findings are consistent with four previous studies that found low levels of knowledge and poor attitudes about the adverse health effects of biomass smoke or other sources of household air pollution amongst people using biomass fuels for their household energy needs.

Table 3. Bivariate variables for good attitude towards preventing harmful effects of biomass fuel smoke.

Predictor variables	Attitude		P-value	OR (95% CI)
	Positive	Negative		
Age group				
16–25	10(18.5)	44(81.5)	0.048*	1
26–35	35 (32.4)	73(67.6)		2.11(0.96–4.65)
36–45	31(33.3)	62(66.7)		2.20(0.98–4.92)
46–55	13(36.1)	23(63.9)		2.49(0.96–6.46)
>55	1(5.9)	16(94.1)		0.27(0.03–2.19)
Sex				
Female	69(42.1)	95(57.9)	0.0001*	1
Male	21(14.6)	123(85.4)		4.25(2.44–7.41)
Marital status				
Ever married	71(33.6)	140(66.4)	0.012*	1
Never married	19(19.6)	78(80.4)		2.08(1.17–3.70)
Level of education				
No formal	8(30.8)	18(69.2)	0.133	1
Primary	29(38.2)	47(61.8)		1.39(0.54–3.54)
Secondary	46(27.5)	121(72.5)		0.86(0.35–2.07)
Tertiary/PG	7(17.9)	32(82.1)		0.49(0.16–1.55)
Monthly income (₦)				
<10000	34(30.4)	78(69.6)	0.005*	1
10000–19999	26 (25.2)	77(74.8)		0.77(0.43–1.28)
20000–29999	15(20.8)	41(73.2)		0.84(0.41–1.71)
30000–39999	3(26.8)	16(84.2)		0.43(0.12–1.52)
≥40000	12(66.7)	6(33.3)		4.59(1.63–12.89)
Duration in present job				
0–5	58(27.9)	150(72.1)	0.222	1
6–10	27(36.0)	48(64.0)		1.45(0.83–2.54)
11–15	4(30.8)	9(69.2)		1.15(0.36–3.71)
>15	1(8.3)	11(91.7)		0.24(0.03–1.71)
Knowledge of harmful effects				
Poor	80(88.9)	136(62.4)	0.0001*	1
Good	10(11.1)	82(37.6)		0.21(0.10–0.42)
Preferred cook fuel				
Biomass	28(32.6)	58(67.4)	0.483	1
Kerosene	33(30.8)	74(69.2)		1.08(0.59–1.99)
Gas	24(27.6)	63(72.4)		1.27(0.66–2.42)
Electricity	5(17.9)	23(82.1)		2.22(0.78–6.35)

*Statistically significant at $p < 0.05$ and the absence of the null value (1.00) from the CIs of the odds ratio.

[11, 45–47].Low levels of knowledge may imply that more health education needs to be done by public health personnel to educate individuals on the harmful effects of biomass smoke.

However, our results contrast with two other studies from different settings which found that there was a high knowledge about the harmful health effects of biomass smoke. The explanation for this inconsistency in the literature may be the smaller sample size used and the purposive nature of sampling in the latter studies. [46–49]

Table 4. Logistic regression for predictors of knowledge and attitude of food vendors.

Variable	OR (95% CI)	p value
KNOWLEDGE		
Age group		
16–25	1	
26–35	1.662(0.570–4.620)	0.365
36–45	1.805(0.486–6.702)	0.377
46–55	2.979(0.595–14.916)	0.184
>55	5.032(0.681–37.184)	0.113
Sex		
Male	1	0.027*
Female	0.490(0.260–0.924)	
Marital status		
Never married	1	
Ever married	0.232(0.097–0.555)	0.001*
Educational level		
No formal	1	
Primary	2.082(0.381–11.392)	0.398
Secondary	5.319(1.017–27.811)	0.048*
Tertiary/PG	23.371(3.505–155.841)	0.001*
Preferred fuel		
Biomass	1	
Kerosene	1.062(0.433–2.604)	0.896
Gas	2.676(1.086–6.593)	0.032*
Electricity	3.568(1.089–11.690)	0.036*
Monthly income		
< 10000	1	
10000–19999	2.798(1.233–6.352)	0.014*
20000–29999	2.113(0.764–5.843)	0.149
30000–39999	2.271(0.526–9.809)	0.272
40000≥	0.906(0.177–4.622)	0.905
Duration in present job	1.089(0.987–1.201)	0.088
ATTITUDES		
Age group		
16–25	1	
26–35	1.544(0.583–4.088)	0.382
36–45	1.183(0.367–3.810)	0.779
46–55	0.928(0.215–4.004)	0.920
>55	0.133(0.10–1.784)	0.128
Sex		
Male	1	
Female	3.179(1.646–6.140)	0.001*
Knowledge of harmful effects		
Good	1	
Poor	0.278(0.117–0.658)	0.004*
Marital status		
Never married	1	
Ever married	1.567(0.720–3.412)	0.258
Educational level		

(*Continued*)

Table 4. (Continued)

Variable	OR (95% CI)	p value
No formal	1	
Primary	1.402(0.480–4.092)	0.537
Secondary	0.850(0.296–2.441)	0.763
Tertiary/PG	1.050(0.235–4.678)	0.949
Preferred fuel		
Biomass	1	
Kerosene	1.425(0.680–2.989)	0.348
Gas	1.719(0.736–4.012)	0.210
Electricity	0.773(0.230–2.603)	0.678
Monthly income		
< 10000	1	
1000–19999	0.975(0.475–1.999)	0.944
20000–29999	1.334(0.538–3.307)	0.534
30000–39999	0.840(0.173–4.085)	0.829
40000≥	6.752(1.722–26.483)	0.006
Duration in present job	1.018(0.926–1.120)	0.708

*Statistically significant and the absence of the null value (1.00) from the CIs of the odds ratio.

https://doi.org/10.1371/journal.pone.0191458.t004

Edelstein and colleagues found a higher proportion of people with positive attitudes about the adverse health effects of biomass smoke compared to our current study although this was a pilot study with limited sample size and included participants from both rural and urban areas.[44] Our findings are consistent with an earlier study done in a rural community which revealed poor attitudes towards reducing household air pollution from sources such as biomass smoke exposure amongst the respondents.[47] Furthermore, studies in other low-middle income countries have shown that having higher levels of education predict better knowledge about the adverse health effects of biomass smoke similar to our findings.[50, 51] It is believed that there is a strong link although not direct between education and disease. This implies the need for advocacy on the need for improved general education in the population. Knowledge of the harmful effects of biomass fuel was a significant predictor of positive attitudes in our study. This is in keeping with a study carrying out in Malaysia looking at attitudes to a form of air pollution which showed some level of correlation between knowledge and attitudes.[29] This is another strong pointer to the need for education, especially to groups of individuals who are exposed to these hazards in the course of their daily trade. Special and routine trainings and education needs of this occupation groups should be a priority to public health officials. In addition, preventing exposure to biomass fuel is a very important principle of prevention. An example of this principle is replacing the use of biomass fuels with less harmful fuel such as cooking gas or electricity. This types of fuels are however more expensive to purchase. This study revealed that persons who used cooking gas and electricity had significantly better knowledge of the harmful effects of biomass fuel. In addition, earning a larger income significantly improved attitudes towards the harmful effects of biomass fuel. This is a strong indication that having more economic power improves health seeking behaviours. Therefore, local authorities need to prioritize on providing cost effective and cleaner cooking fuels to these food vendors who are mostly in the lower socio-economic class.

Strengths of our study include the large sample size from two cities, the inclusion of men and women, and a wide age range. The study would have been strengthened by including

qualitative research methods such as in-depth interviews and focus group discussions. This would have given the opportunity to explore from the respondent's perspectives on other socio-cultural issues that can influence the level of knowledge and attitudes to biomass smoke exposure.

A limitation of this study was that responses made by the food vendors were based on self-report and it was difficult to authenticate some of their responses. The inclusion of objective assessments of vendors' exposure to biomass smoke and their respiratory health would have added additional value. Other limitation of our current work was the non-measurement of their knowledge and attitudes to other sources of outdoor air pollution as well as the level of outdoor air pollution the food vendors may have been exposed to. This could potentially influence their knowledge and attitudes to biomass smoke and other sources of air pollution.

It is recommended that future studies should explore the knowledge and attitudes of food vendors to other environmental sources of air pollution that their occupation predispose them to and its potential effect on their health using a mixed method approach.

Our study has demonstrated that, despite the evidence available regarding the health effects of biomass fuel smoke, the message may still be largely within the domain of researcher and policy makers. This is of great concern as awareness and knowledge of this issue is necessary to change behaviours towards adoption of cleaner sources of energy and reducing household air pollution exposure.

In conclusion, we found that Nigerian commercial food vendors have limited knowledge about the health hazards of their occupation-associated use of biomass fuels and have negative attitudes towards preventing these adverse effects despite high levels of belief that these fuels are harmful to health. There is a need for evidence-based interventions such as implementing health education campaigns using compelling messages distributed via short-message-services (SMS),vendor's involvement in air quality monitoring reading and interpretation, conditional cash transfer to improve knowledge, attitudes and beliefs about the adverse health effects of biomass smoke and to develop effective and cost-effective alternatives to biomass fuels for commercial food vendors in Nigeria and elsewhere in Africa.

Supporting information

S1 File. File containing study questionnaire.
(DOC)

S2 File. File containing dataset.
(XLS)

Author Contributions

Conceptualization: Ogonna N. O. Nwankwo, Ndubuisi Mokogwu, Orighomisan Agboghoroma, Fahmi O. Ahmed, Kevin Mortimer.

Data curation: Ogonna N. O. Nwankwo, Ndubuisi Mokogwu.

Formal analysis: Ogonna N. O. Nwankwo, Ndubuisi Mokogwu.

Funding acquisition: Ogonna N. O. Nwankwo, Ndubuisi Mokogwu, Orighomisan Agboghoroma, Fahmi O. Ahmed, Kevin Mortimer.

Investigation: Ogonna N. O. Nwankwo, Ndubuisi Mokogwu.

Methodology: Ogonna N. O. Nwankwo, Ndubuisi Mokogwu, Orighomisan Agboghoroma, Kevin Mortimer.

Project administration: Ogonna N. O. Nwankwo, Ndubuisi Mokogwu.

Resources: Ogonna N. O. Nwankwo, Ndubuisi Mokogwu, Kevin Mortimer.

Software: Ogonna N. O. Nwankwo, Ndubuisi Mokogwu.

Supervision: Ogonna N. O. Nwankwo, Ndubuisi Mokogwu, Kevin Mortimer.

Validation: Ogonna N. O. Nwankwo, Ndubuisi Mokogwu, Kevin Mortimer.

Visualization: Ogonna N. O. Nwankwo, Ndubuisi Mokogwu, Orighomisan Agboghoroma, Fahmi O. Ahmed, Kevin Mortimer.

Writing – original draft: Ogonna N. O. Nwankwo, Ndubuisi Mokogwu, Kevin Mortimer.

Writing – review & editing: Ogonna N. O. Nwankwo, Ndubuisi Mokogwu, Orighomisan Agboghoroma, Fahmi O. Ahmed, Kevin Mortimer.

References

1. UNDP, World Health Organization. The energy access situation in developing countries: A Review focusing on the Least Developed Countries and Sub-Saharan Africa. 2009.

2. IARC. IARC monographs on the evaluation of carcinogenic risks to humans. Volume 109. Outdoor air pollution. Lyon: International Agency for Research on Cancer 2016.

3. Lim SS, Vos T, Flaxman AD, Danaei G, Shibuya K, Adair-Rohani H, et al. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet. 2012; 380(9859):2224–60. https://doi.org/10.1016/S0140-6736(12)61766-8 PMID: 23245609

4. Loomis D, Grosse Y, Lauby-Secretan B, El Ghissassi F, Bouvard V, Benbrahim-Tallaa L, et al. The carcinogenicity of outdoor air pollution. The Lancet Oncology. 2013; 14(13):1262–3. PMID: 25035875

5. WHO. Ambient air pollution:A global assessment of exposure and burden of disease. Geneva: 2016.

6. Torres-Duque C, Maldonado D, Perez-Padilla R, Ezzati M, Viegi G. Biomass fuels and respiratory diseases: a review of the evidence. Proceedings of the American Thoracic Society. 2008; 5(5):577–90. https://doi.org/10.1513/pats.200707-100RP PMID: 18625750

7. Mortimer K, Gordon SB, Jindal SK, Accinelli RA, Balmes J, Martin WJ 2nd. Household air pollution is a major avoidable risk factor for cardiorespiratory disease. Chest. 2012; 142(5):1308–15. https://doi.org/10.1378/chest.12-1596 PMID: 23131939

8. Gordon SB, Bruce NG, Grigg J, Hibberd PL, Kurmi OP, Lam, et al. Respiratory risks from household air pollution in low and middle income countries. The Lancet Respiratory Medicine. 2014; 2(10):823–60. https://doi.org/10.1016/S2213-2600(14)70168-7 PMID: 25193349

9. Brauer M, Freedman G, Frostad J, van Donkelaar A, Martin RV, Dentener F, et al. Ambient Air Pollution Exposure Estimation for the Global Burden of Disease 2013. Environmental science & technology. 2016; 50(1):79–88.

10. Piddock KC, Gordon SB, Ngwira A, Msukwa M, Nadeau G, Davis KJ, et al. A cross-sectional study of household biomass fuel use among a periurban population in Malawi. Annals of the American Thoracic Society. 2014; 11(6):915–24. https://doi.org/10.1513/AnnalsATS.201311-413OC PMID: 24960156

11. Isara AR, Aigbokhaode AQ. Household Cooking Fuel Use among Residents of a Sub-Urban Community in Nigeria: Implications for Indoor Air Pollution. The Eurasian journal of medicine. 2014; 46(3):203–8. https://doi.org/10.5152/eajm.2014.0051 PMID: 25610326

12. Fullerton DG, Bruce N, Gordon SB. Indoor air pollution from biomass fuel smoke is a major health concern in the developing world. Transactions of the Royal Society of Tropical Medicine and Hygiene. 2008; 102(9):843–51. https://doi.org/10.1016/j.trstmh.2008.05.028 PMID: 18639310

13. Mortimer K, Ndamala CB, Naunje AW, Malava J, Katundu C, Weston W, et al. A cleaner burning biomass-fuelled cookstove intervention to prevent pneumonia in children under 5 years old in rural Malawi (the Cooking and Pneumonia Study): a cluster randomised controlled trial. The Lancet. 2017; 389 (10065):167–75.

14. Lee A, Adobamen PROC, Agboghoroma O, Ahmed FO, Aigbokhaode A, Amusa GA, et al. Household air pollution: a call to action. The Lancet Respiratory Medicine. 2015; 3(1):e1–e2. https://doi.org/10.1016/S2213-2600(14)70288-7 PMID: 25593091

15. WHO. Deaths from household air pollution 2012. Available from: www.who.int/phe/health. . ./outdoorair/
. . ./FINAL_HAP_AAP_BoD_24March2014.pdf

16. Okojie PW, Isah EC. Sanitary conditions of food vending sites and food handling practices of street food vendors in Benin City, Nigeria: implication for food hygiene and safety. Journal of environmental and public health. 2014; 2014:701316. https://doi.org/10.1155/2014/701316 PMID: 25258630

17. Oyunga-Ogubi M, Waudo N, Afullo A, Oiye S. Street foods in nairobi, kenya: Their role as a source of micronutrients in low income groups. African Journal of food Agriculture nutrition and development. 2009; 9(4):207.

18. FAO. Promises and challenges of the informal food sector in developing countries. 2007.

19. Adewole OO, Desalu OO, Nwogu KC, Adewole TO, Erhabor GE. Respiratory Symptoms and Lung Function Patterns in Workers Exposed to Wood Smoke and Cooking Oil Fumes (Mai Suya) in Nigeria. Annals of Medical and Health Sciences Research. 2013; 3(1):38–42. https://doi.org/10.4103/2141-9248.109475 PMID: 23634327

20. Dienye P, Akani A, Okokon I. Respiratory effects of biomass fuel combustion on rural fish smokers in a Nigerian fishing settlement: a case control study. African Health Sciences. 2016; 16(2):516–23. https://doi.org/10.4314/ahs.v16i2.20 PMID: 27605967

21. Awopeju O, Erhabor G, Obaseki D, Adewole O. Respiratory Health Of Nigerian Women Occupationally Exposed To Biomass Fuel: A Comparative Study. Am J Respir Crit Care Med; 189:A5217. 2014.

22. Mbatchou Ngahane BH, Afane Ze E, Chebu C, Mapoure NY, Temfack E, Nganda M, et al. Effects of cooking fuel smoke on respiratory symptoms and lung function in semi-rural women in Cameroon. International journal of occupational and environmental health. 2015; 21(1):61–5. https://doi.org/10.1179/2049396714Y.0000000090 PMID: 25384259

23. Akani AB, Dienye PO, Okokon IB. Respiratory symptoms amongst females in a fishing settlement in the Niger Delta, Nigeria. African Journal of Primary Health Care & Family Medicine. 2011; 3(1):152.

24. Reynolds KD, Spruijt-Metz D, Unger J. Health Behaviour Research Interventions. In: Wallace RB, Kohatsu N, editors. Maxcy-Rosenau-Last Public Health and Preventive Medicine. 15th ed. ed. New York: McGraw-Hill medical; 2008.

25. Fransson N, GÄRling T. Environmental concern: Conceptual definitions, measurement methods, and research findings. Journal of Environmental Psychology. 1999; 19(4):369–82.

26. Claessen J-P, Bates S, Sherlock K, Seeparsand F, Wright R. Designing interventions to improve tooth brushing. International Dental Journal. 2008; 58(S5):307–20.

27. Ajzen I. Perceived Behavioral Control, Self-Efficacy, Locus of Control, and the Theory of Planned Behavior1. Journal of Applied Social Psychology. 2002; 32(4):665–83.

28. Baranowski T, Cullen KW, Nicklas T, Thompson D, Baranowski J. Are Current Health Behavioral Change Models Helpful in Guiding Prevention of Weight Gain Efforts? Obesity Research. 2003; 11 (S10):23S–43S.

29. Pretto LD, Acreman S, Ashfold MJ, Mohankumar SK, Campos-Arceiz A. The Link between Knowledge, Attitudes and Practices in Relation to Atmospheric Haze Pollution in Peninsular Malaysia. PloS one. 2015; 10(12): e0143655. https://doi.org/10.1371/journal.pone.0143655 PMID: 26646896

30. Nguyen SP, Gordon CL, McCullough MB. Not as easy as pie. Disentangling the theoretical and applied components of children's health knowledge. Appetite. 2011; 56(2):265–8. https://doi.org/10.1016/j.appet.2011.01.008 PMID: 21232567

31. Haron SA, Paim L, Yahaya N. Towards sustainable consumption: an examination of environmental knowledge among Malaysians. International Journal of Consumer Studies. 2005; 29(5):426–36.

32. Dominick GM, Dunsiger SI, Pekmezi DW, Marcus BH. Health literacy predicts change in physical activity self-efficacy among sedentary Latinas. Journal of immigrant and minority health. 2013; 15(3):533–9. https://doi.org/10.1007/s10903-012-9666-7 PMID: 22733230

33. Staiano A, Reeder B, Elliott S, Joffres M, Pahwa P, Kirkland S, et al. Knowing is half the battle: Heart health and exercise knowledge protect against mortality. Journal of Science and Medicine in Sport. 2012; 15:S177.

34. Ekeke N, Meka A, Chukwu J, Nwafor N, Alphonsus C, Mbah O, et al. Assessment of health care workers' knowledge, attitude and risk perception of Buruli ulcer disease in Southern Nigeria. Transactions of the Royal Society of Tropical Medicine and Hygiene. 2017; (https://doi.org/10.1093/trstmh/trx049) PMID: 28957473

35. Semenza JC, Wilson DJ, Parra J, Bontempo BD, Hart M, Sailor DJ, et al. Public perception and behavior change in relationship to hot weather and air pollution. Environmental research. 2008; 107(3):401–11. https://doi.org/10.1016/j.envres.2008.03.005 PMID: 18466894

36. Vulturius G, Wanjiru H. The role of social relations in the adoption of improved cookstoves. Stockholm environment institute working paper no 2017–01. 2017.

37. Thompson LM. Cooking with gas:How children in the developing world benefit from switching to LPG. World LPG Association, 2015.Available from: www.wlpga.org/wp-content/uploads/2015/09/cooking-with-gas-how-children-in-the-developing-world-benefit-from-switching-to-lpg.pdf.

38. Rehfuess EA, Puzzolo E, Stanistreet D, Pope D, Bruce NG. Enablers and barriers to large-scale uptake of improved solid fuel stoves: a systematic review. Environmental health perspectives. 2014; 122 (2):120–30. https://doi.org/10.1289/ehp.1306639 PMID: 24300100

39. National Population Commission (NPC) [Nigeria], ICF International. Nigeria Demographic and Health Survey 2013. Abuja, Nigeria, and Rockville, Maryland, USA: NPC and ICF International. 2014.

40. National Bureau of Statistics. Annual abstract of Statistics,2012. Abuja: 2013.

41. World Bank. GNI per capita, Atlas method (current US$). 2016. Available from: https://data.worldbank.org/country/nigeria?view=chart.

42. Iwu AC, Uwakwe KA, Duru CB, Diwe KC, Chineke HN, Merenu IA, et al. Knowledge, Attitude and Practices of Food Hygiene among Food Vendors in Owerri, Imo State, Nigeria. Occupational Diseases and Environmental Medicine. 2017; 05(01):11–25.

43. WHO. Evaluating household energy and health interventions: A catalogue of methods,. 2008.

44. Edelstein M, Pitchforth E, Asres G, Silverman M, Kulkarni N. Awareness of health effects of cooking smoke among women in the Gondar Region of Ethiopia: a pilot survey. BMC international health and human rights. 2008; 8:10. https://doi.org/10.1186/1472-698X-8-10 PMID: 18644103

45. Krupa K, Piekut A, Złotkowska R. Assessment of risk perception connected with exposure to indoor air pollution in the group of inhabitants of Silesian Voivodeship.Environmental Medicine 2012.2012; 15(3).

46. Mobarak AM, Dwivedi P, Bailis R, Hildemann L, Miller G. Low demand for nontraditional cookstove technologies. Proceedings of the National Academy of Sciences of the United States of America. 2012; 109(27):10815–20. https://doi.org/10.1073/pnas.1115571109 PMID: 22689941

47. Osagbemi G, Adebayo Z, Aderibigbe S. Awareness, attitude and practice towards indoor air pollution (IAP) amongst residents of Oke–oyi in Ilorin. The Internet Journal of Epidemiology. 2009; 8(2).

48. Alim M, Nurunnabi A, Ahmad S, Khan M, Ahmad S. Knowledge of health hazards and perception of prevention amongst females exposed to biomass fuel and gas/electricity fuel in a district of Bangladesh. AKMMC J 2013; 4(1):20–4.

49. Afolabi OT, Awopeju OF, Aluko O, Deji S, Olaniyan B, Agbakwuru L, et al. Awareness of indoor air pollution and prevalence of respiratory symptoms in an urban community in South West Nigeria Nigerian Journal of Health sciences. 2016; 16(1):3338.

50. Egondi T, Kyobutungi C, Ng N, Muindi K, Oti S, van de Vijver S, et al. Community perceptions of air pollution and related health risks in Nairobi slums. International journal of environmental research and public health. 2013; 10(10):4851–68. https://doi.org/10.3390/ijerph10104851 PMID: 24157509

51. Jin Y, Ma X, Chen X, Cheng Y, Baris E, Ezzati M, et al. Exposure to indoor air pollution from household energy use in rural China: the interactions of technology, behavior, and knowledge in health risk management. Social science & medicine. 2006; 62(12):3161–76.