EFFECTS OF BIOMASS COOKING FUELS ON THE RESPIRATORY HEALTH OF HOUSEHOLD MEMBERS IN ENUGU STATE, NIGERIA

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ABSTRACT

Background of the Study: A large proportion of households rely on biomass fuels for cooking and space heating. Combustion of biomass fuels emit a mixture of health-damaging air pollutants capable of impacting negatively on the human health.

Aim of the Study: This study was carried out to ascertain the harmful effects which the use of biomass cooking fuels inflicts on the respiratory health of household members in Enugu State of Nigeria.

Materials and Methods: A multistage, stratified, and systematic random sampling was used in this cross-sectional study, which included 502 respondents from 232 households in 6 of Enugu State's 17 Local Government Areas (LGAs). A semi-structured questionnaire was used to collect information about respondents' socio-demographics, cooking fuel type, cooking apparatus/stove, and so on. Certified medical personnel observed and evaluated the respondents for nasal irritation and chronic obstructive pulmonary disease.

Results: Of the 502 participants in the study, 248 (49%) had respiratory health issues such as nasal irritation or chronic obstructive pulmonary diseases. Respiratory problems were more common among those who cook with biomass (48%) than those who cook with fossil fuels (0.8%). Compared to fossil fuels (liquefied petroleum gas and kerosene), 95% of the study population use biomass as the preferred cooking fuel, out of which 73% use unprocessed wood. The highest prevalence of respiratory health outcomes was observed among biomass users who cook with unprocessed wood (37.5%).

Conclusions: The findings of this study indicate a high reliance on biomass fuels, which may have resulted in a significant manifestation of its effects on the population's respiratory health. This study clearly shows that those who use biomass cooking fuels have worse respiratory health outcomes. This implies that these biomass cooking fuels emit high levels of air pollutants, which are harmful to the respiratory health of the users.

Key Words: Air pollution, biomass, smoke, cooking fuel, respiratory health

INTRODUCTION:

In most developing countries, including Nigeria, large proportions of households rely on biomass fuels for cooking and space heating. Almost half of the world's populations, who live in low-income regions, use biomass (wood, crop residues, and animal dung) as their primary fuel for cooking[1]. These biomass cooking fuels present a major global public health threat, resulting in an estimated 1.6 million deaths annually, women and children being the worst hit[2,3]. Combustion of biomass fuels emit a mixture of health-damaging air pollutants including carbon monoxide (CO), sulphur dioxide, nitrogen dioxide (NO_2), and many other toxic organic compounds and respirable particulate matter capable of impacting negatively on the health of man[4, 5]. According to the World Health Organization, air pollution from household fuel combustion is the most important global environmental health risk today. Almost 3 billion of the world's poorest people still rely on solid fuels (wood, animal dung, charcoal, crop wastes and coal) burned in inefficient and highly polluting stoves for cooking and heating, currently resulting in some 4 million premature deaths annually among children and adults from respiratory and cardiovascular diseases, and cancer[6].

Chronic exposure to biomass smoke has been associated with multiple adverse health effects, including chronic bronchitis, chronic obstructive pulmonary disease (COPD), acute lower respiratory infection (ALRI), lung cancer, reduced birth weight and cataracts[7-9]. Specifically, use of biomass fuel is a significant risk factor for respiratory disease, and household air pollution (HAP)-related COPD has been estimated to result in 800,000 premature deaths per year globally [6; 8, 10]. The most vulnerable group are the women cooks who spend maximum time in the kitchen area during cooking hours and small children accompanying them during that time[11]. This dependence on solid biomass fuel leads to indoor air pollution which is now recognized as a major threat to human health. Around 42.2% of the population is exposed to household air pollution (HAP) in most of the middle and low-income countries and it ranks as the eighth greatest risk factor causing morbidity and mortality[12].

In Nigeria, it is estimated by the WHO that 79,000 deaths per year occur from indoor air pollution, mainly caused by biomass burning[11]. Deaths from

acute lower respiratory infection in children under 5 years of age account for about 90% of the total number of deaths from indoor air pollution, with chronic obstructive pulmonary disease (COPDs) in adults of ≥ 30 years accounting for the rest [13,14]. Furthermore, constant search for fuel wood represents a large burden for women, particularly in rural areas[15]. This current study was therefore aimed at investigating the impact of the widespread use of solid biomass fuels for cooking and space heating on the respiratory health of communities in Enugu State, Nigeria.

MATERIALS AND METHODS:

Scope of the Study: This cross-sectional research studied occupants of households and their use of biomass cooking fuels, in 6 Local Government Areas (LGAs) spread across the (3) Senatorial Zones in Enugu State, Nigeria. The selected LGAs include – Enugu-East and Isi-Uzo from Enugu East Senatorial District; Nsukka and Igboeze South from Enugu North Senatorial District; whereas Aninri and Awgu LGAs were selected from Enugu West Senatorial District.

Study Area: This cross-sectional study was conducted in Enugu State of Nigeria. The State is one of the states in Nigeria's southeastern region. It has 17 LGAs and a total population of 3,267,837 people[16]. Fourteen (14) of the seventeen (17) LGAs are primarily rural. Some urban towns are concentrated primarily within the State capital. The state's economy is predominantly rural and agrarian, as it is mostly covered by open grassland with occasional woodlands and clusters of oil palm trees. Farming employs a sizable proportion of the working population, but trading (18.8 percent) and services (12.9 percent) are also important[17]. Enugu State and other states in Southeastern Nigeria are commonly referred to as Igbo land because the people are primarily Igbos with distinct ingenious characteristics. Due to the abundant rainfall in the

Figure 1: Map of Enugu State Showing the 17 Local Government Areas[18]

Sample Size: In the determination of sample size for this research work, the Fisher's formula: $n = Z^2 q(1-p)/d^2$ for a large population ($>1,000$) was adopted [17]. Where n = minimum sample size; Z = standard normal deviation usually set at 1.96 which corresponds to the 95% confidence level; p = assumed population prevalence in % (the population of the study is estimated to be 50% to represent the target population in this study); q = 1-p; d = maximum acceptable random sampling error in %. In this case, P= 50%= 0.5; q = 1- 0.5 =0.5; d = 5%= 0.05. Therefore, sample size (n) = $(1.96)^2$ (0.50) (0.50) / $(0.05)^2$ = 384.

Study population: A sample size of 384 was calculated using Fisher's formula. As a result, 232 households and 502 individual respondents were sampled, which was considered a good representation of the population under study. Respondents provided information on socio-demographics, type of cooking fuel used, family structure, type of cooking apparatus/stove, ventilation status of the house, cooking hours/day and average family income. Male and female members of the selected households took part in the study. Participants under the age of 14 and those over the age of 70 were excluded from the study.

Sampling Techniques: In this cross-sectional study, a multistage and stratified random sampling method was used to select 6 LGAs from the state, consisting 2 LGAs from each of the 3 senatorial districts. Enugu-East and Isi-Uzo LGAs were selected from the Enugu-East Senatorial District; Nsukka and Igboeze South LGAs were selected from the Enugu-North Senatorial District; and Aninri and Awgu LGAs were selected from the Enugu-West Senatorial District. Simple random sampling was then used to select the Wards and settlements for the study. Three (3) Electoral Wards each were selected from Enugu-East, Isi-Uzo, Igboeze-South, and Aninri LGAs, while and two Electoral Wards each were selected from Nsukka and Awgu LGAs, totaling 16 Wards studied. Nine (9) settlements were selected from Enugu-East, Isi-Uzo, Igboeze-South, and Aninri LGAs, while five (5) settlements were selected from Nsukka and four (4) settlements were selected from Awgu LGA, totaling 45 settlements studied. Systematic sampling technique was used to select households within the settlements where the research instruments were administered. The households sampled in each settlement were determined using McCombes' systematic sampling technique model, in which the first household is chosen at random and the subsequent ones are chosen at intervals of 10th household in a defined order[19]. An average of 5 households from each of the 45 settlements participated in the study, making a total of 232 households. The assessment were carried out among different age groups in any selected household, namely: 14- 23; 24-33, 34-43, 44-53, 54-63, 64 - ≤70 years, involving both male and female. This study enlisted the participation of 502 people, including 146 males and 356 females. The data gathered from these sources was analyzed to arrive at the study's findings and conclusion.

Ethical Consideration: The Ethics and Research Committee of the Abia University Teaching Hospital in Aba, Nigeria, granted ethical approval (**ABSUTH/MAC/117/Vol.1/61**) for the study. Each respondent provided informed written consent. Respondents' confidentiality and privacy were maintained throughout the study.

Measurement of Respiratory Health Outcomes: Certified medical personnel observed and evaluated the respondents for nasal irritation and chronic obstructive pulmonary disease. Shortness of breath, cough, dizziness, eye and nasal irritation, body ache, frequent headache, and visible symptoms of respiratory diseases were all taken into account.

Statistical Analysis: The mean values of the collected data were calculated using Statistical Package for Social Sciences (SPSS) version 21.0.

RESULTS:

Table 1 shows the socio-demographics of the study area. It reveals that 75% of respondents live in rural areas. It also shows that the majority of those who cook for their families are females (71%). A larger proportion (28%) of respondents were between the ages of 34 and 43, followed by 25% of respondents between the ages of 14 and 23.

The types of cooking fuels used in Enugu State are shown in Table 2 and Figure 2. It can be seen that biomass fuels constitute 95% of cooking fuels used in the state. Unprocessed wood (firewood) was the most popular cooking fuel, used by 73% of the study population, followed by charcoal (21%). Saw dust, which was used by 1% of the respondents, was the least preferred cooking fuel. The least preferred cooking fuel was saw dust, which was used by 1% of the study population. It can also be seen that only 6% of the population uses fossil fuels, with 4% using liquefied petroleum gas (LPG) and 2% using kerosene for cooking.
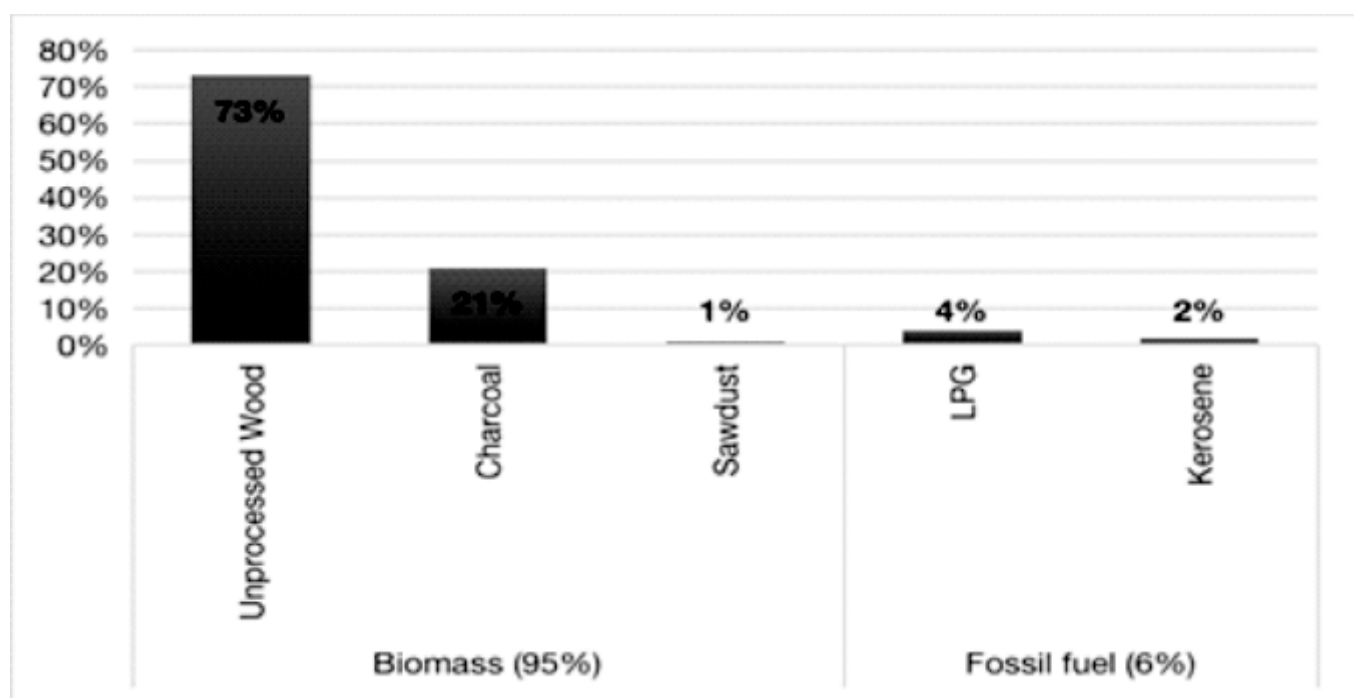
Table 3 shows the respiratory outcomes of household members who use biomass and fossil cooking fuels in Enugu State. According to the findings, 248 (49%) of the 502 participants in the study had respiratory health issues such as nasal irritation or COPD. Respiratory problems were more common among those who cook with biomass [244(48%)] than among those who cook with fossil fuels [4(0.8%)].

Table 1: Demographics of the Sample Population

Demographics of Respondents		Local Government Area (LGA)						Total
		Aninri	Awgu	Enugu-East	Igboeze-South	Isi-Uzo	Nsukka	
Social Setting	Rural	80(16%)	0(0%)	50(10%)	100(20%)	80(16%)	64(13%)	374(75%)
	Urban	0(0%)	40(8%)	88(18%)	0(0%)	0(0%)	0(0%)	128(25%)
	Subtotal	80(16%)	40(8%)	138(27%)	100(20%)	80(16%)	64(13%)	502(100%)
Gender	Male	22(4%)	5(1%)	38(8%)	34(7%)	27(5%)	20(4%)	146(29%)
	Female	58(12%)	35(7%)	100(20%)	66(13%)	53(11%)	44(9%)	356(71%)
	Subtotal	80(16%)	40(8%)	138(27%)	100(20%)	80(16%)	64(13%)	502(100%)
Age Distribution	14 – 23	7(1%)	15(3%)	26(5%)	44(9%)	25(5%)	8(2%)	125(25%)
	24 – 33	19(4%)	5(1%)	24(5%)	10(2%)	13(3%)	8(2%)	79(16%)
(in years)	34 – 43	19(4%)	5(1%)	46(9%)	30(6%)	19(4%)	24(5%)	143(28%)
	44 – 53	3(1%)	10(2%)	24(5%)	12(2%)	17(3%)	4(1%)	70(14%)
	54 – 63	29(6%)	5(1%)	16(3%)	4(1%)	6(1%)	20(4%)	80(8%)
	64 - <70	3(1%)	0(0%)	2(1%)	0(0%)	0(0%)	0(0%)	5(1%)
	Subtotal	80(16%)	40(8%)	138(27%)	100(20%)	80(16%)	64(13%)	502(100%)

Table 2: Types of Cooking Fuel Used by the Respondents

Fuel Types		Local Government Area (LGA)						Total
		Aninri	**Awgu**	**Enugu East**	**Igboeze South**	**Isi-Uzo**	**Nsukka**	
Biomass	**Unprocessed Wood**	53(11%)	32(6%)	80(16%)	80(16%)	71(14%)	48(10%)	364(73%)
	Charcoal	20(5%)	8(2%)	30(6%)	20(5%)	9(2%)	16(3%)	103(21%)
	Sawdust	0(0%)	0(0%)	6(1%)	0(0%)	0(0%)	0(0%)	6(1%)
	Subtotal	73(15%)	40(8%)	116(23%)	100(20%)	80(16%)	64(13%)	473(94%)
Fossil fuel	**LPG**	3(1%)	0(0%)	18(2%)	0(0%)	0(0%)	0(0%)	21(4%)
	Kerosene	4(1%)	0(0%)	4(1%)	0(0%)	0(0%)	0(0%)	8(2%)
	Subtotal	7(2%)	0(0%)	22(5%)	0(0%)	0(0%)	0(0%)	29(6%)
Total (n)		80(16%)	40(8%)	138(27%)	100(20%)	80(16%)	64(13%)	502(100%)

Figure 2: Primary Cooking Fuels Used by Residents of Enugu State

Table 3: R espiratory Outco mes Among Members of Households Using Biomass and Fossil Cooking Fuels in Enugu State

Local Government Area (LGA)	Biomass Fuels						Fossil Fuels				Total
	Unprocessed Wood		Charcoal		Saw Dust		Kerosene		LPG		
	Nasal irritation [n(%)]	COPD [n(%)]	Nasal irritation [n(%)]	COPD [n(%)]	Nasal irritation [n(%)]	COPD [n(%)]	Nasal irritation [n(%)]	COPD [n(%)]	Nasal irritation [n(%)]	COPD [n(%)]	
Aninri	16(3%)	0(0%)	7(1.4%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	23(4.4%)
Awgu	20(4%)	9(1.7%)	3(0.6%)	1(0.2%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	33(6.5%)
Enugu East	24(5%)	8(1.5%)	12(2.4%)	4(0.8%)	4(0.8%)	2(0.4%)	0(0%)	0(0%)	4(0.8%)	0(0%)	58(11.7%)
Igboeze South	40(8%)	10(1.9%)	10(1.9%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	60(11.8%)
Isi-Uzo	36(7%)	8(1.6%)	2(0.4%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	46(9%)
Nsukka	4(0.8%)	16(3%)	0(0%)	8(1.6%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	28(5.4%)
Total	140(27.8%)	51(9.7%)	34(6.7%)	13(2.6%)	4(0.8%)	2(0.4%)	0(0%)	0(0%)	4(0.8%)	0(0%)	248(48.8%)

DISCUSSION:

According to the Economic Community of West African States (ECOWAS), Centre for Renewable Energy and Energy Efficiency (ECREEE), approximately 80% of the ECOWAS population still cooks with traditional biomass. This is mostly done inefficiently, leaving children and women vulnerable to health issues that can lead to death[20].

Nigeria is not immune to this problem, as more than 75% of the Nigerian population, particularly in rural areas, still uses the traditional cooking method of using wood fuel[21].

According to the study population's demography (Table 1), 75% of respondents live in rural areas, and the majority (71%) of study participants who cook are women. The majority of the study population is

between the ages of 34 and 43 (28%). This reflects a very young population that, all things being equal, should be very healthy.

Table 2 and Figure 2 show that 95% of the study population uses biomass as their primary cooking fuel, with 73% using unprocessed wood. Among the three biomass fuels investigated (unprocessed wood, charcoal, and sawdust), unprocessed wood (firewood) was used as a cooking fuel by the vast majority (73%) of the sample population. Only 6% of the population uses fossil fuels (LPG and kerosene), with LPG, considered the cleanest cooking fuel in this study, being used by 4% of the study population.

Manifestation of nasal irritation and or chronic obstructive pulmonary diseases (COPD), were used as indicators of occurrence of respiratory outcome in respondents. In Table 3, it can be observed that of the 502 respondents who participated in the study, 248(49%) had respiratory health issues that were either nasal irritation or COPD. Respiratory problems were prevalent among a great proportion of the study participants who cook with biomass [244(48%)], compared to those who use fossil fuels [4(0.8%)].

The presence of nasal irritation and/or chronic obstructive pulmonary disease (COPD) in respondents was used as an indicator of the occurrence of respiratory issues. According to Table 3, 49% of the 502 participants in the study had respiratory health issues, which were either nasal irritation or COPD. The respiratory problems were more common among those who cook with biomass than among those who cook with fossil fuels.

Table 3 also shows that residents of Aninri LGA had the lowest rate of respiratory issues (4.4%). Residents of Igboeze South (11.8%) and Enugu East (11.7%) LGAs accounted for the majority of those

suffering from respiratory health problems. These two LGAs accounted for the greatest number of users of biomass fuel, with processed wood being the most popular (Table 2).

The highest prevalence of respiratory health outcomes was observed among biomass users who cook with unprocessed wood [191(37.5%)], followed by those who cook with charcoal [47(5.3%)] and those who cook with sawdust [6(1.2%)]. When compared to individuals who cook with biomass, respondents who cook with fossil fuels had significantly fewer respiratory problems. Only 0.8% of all respondents with respiratory health issues [248(49%)] used fossil fuels (Table 3).

The findings of this study indicate a high reliance on biomass fuels, which may have resulted in a significant manifestation of its effects on the population's respiratory health. This study clearly shows that those who use biomass cooking fuels have worse respiratory health outcomes. This is consistent with the findings of many other researchers who discovered that chronic exposure to biomass smoke is associated with a variety of negative health effects, including chronic bronchitis, COPD, acute lower respiratory infection (ALRI), lung cancer, low birth weight, and cataracts[7-9]. Although nasal irritation and COPDs can be a random disease in rural areas, the findings of this study show that the respiratory health issues observed in study participants were linked to biomass use. The fact that the majority of respondents stated that they only experience respiratory irritations while cooking, as well as the young and supposedly health study population, strongly suggests that these health issues are caused by the cooking fuel type.

It is recommended that government at all levels make provisions for clean, modern, and reliable

cooking fuels such as electricity and LPG to be readily available and affordable for household consumption as an alternative to biomass fuels. All of these are required for Nigeria to significantly reduce the number of deaths and illnesses caused by hazardous chemicals and air pollution, as stated in SDG 3-target 3.9.

To ensure that the negative health effects of household fuel combustion are reduced or eliminated, the guidelines for indoor air quality/household fuel combustion should be considered and adopted by households, as well as enforced by relevant authorities[22].

Because firewood is the preferred fuel for the majority of the rural population, Nigeria and other third-world countries should implement a permanent and deliberate reforestation program that includes the planting of wood species that are ecologically suitable, socio-culturally compatible, and economically viable.

CONCLUSION

According to the findings of this study, respondents who use unprocessed wood as their cooking fuel have the highest incidences of nasal irritation and chronic obstructive pulmonary disease, followed by those who cook with charcoal and then those who cook with sawdust. This implies that biomass cooking fuels may emit high levels of air pollutants, which may have a negative impact on the users' respiratory health. It was also discovered that respondents who cook with clean fuels have very few or no respiratory health issues.

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