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Household biomass fuel use and associated visual impairment in Enugu state, Nigeria

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Abstract

Background: Biomass fuels are widely used for household cooking in developing countries and are a major source of indoor air pollution. Exposure to biomass smoke has been associated with adverse health outcomes, but its relationship with ocular health remains under-explored in Nigeria.

Aim: This study investigated the prevalence of visual defects among household members using biomass cooking fuels in Enugu State, Nigeria.

Methods: A community-based cross-sectional study was conducted among 502 respondents from 232 households across six Local Government Areas (LGAs) in Enugu State. Multistage sampling was used to select households. Data were collected using structured questionnaires and ocular examinations, including visual acuity assessment by an ophthalmologist, using Snellen chart. Associations between cooking fuel types and visual defects were analysed using chi-square tests and odds ratios (OR) with 95% confidence intervals (CI).

Results: Biomass fuels were used by 94% of households, with firewood being the predominant fuel (73%). Visual defects (mainly cataract, glaucoma, and pterygium) were observed in 32.6% of firewood users and 11.4% of charcoal users, while no cases were observed among sawdust users. Firewood use was strongly associated with visual defects compared with non-biomass fuels (OR = 17.5; 95% CI: 9.8–31.2; $p < 0.001$).

Conclusion: Biomass fuel use, particularly unprocessed firewood, is associated with a higher prevalence of visual defects among household members in Enugu State. Promotion of cleaner cooking fuels and improved combustion technologies is essential to reduce ocular health risks.

Keywords: Biomass Fuels; Visual Defects; Indoor Air Pollution; Ocular Health; Epidemiology; Public Health

1. Introduction

Biomass fuels are renewable carbon-based materials derived from plant or animal sources that produce thermal energy when burned. In Nigeria and many developing countries, over 75% of households rely on biomass fuels for cooking and space heating due to their availability and low cost [1,2]. Globally, 2.6 billion people use unclean cooking fuels, such as wood, charcoal, and agricultural residues, due to lack of access to modern energy sources [3]. In Nigeria, biomass fuels

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are free or relatively inexpensive, this accounts for their widespread use in countries with high level of poverty levels [4,5].

Household air pollution resulting from biomass combustion is a major environmental risk factor and has been linked to respiratory, cardiovascular, and ocular diseases [6,7]. Biomass smoke contains particulate matter, carbon monoxide, formaldehyde, and other toxic compounds capable of inducing oxidative stress and inflammatory responses in ocular tissues [8–10]. Common ocular complaints among exposed populations include eye irritation and redness, which may precede more severe visual disorders such as cataract, glaucoma, and pterygium [11,12].

Although respiratory effects of biomass smoke are well documented, its impact on ocular health is less understood. Visual impairment, including cataract, glaucoma, and pterygium, significantly reduce quality of life and workforce productivity and can lead to blindness if untreated [12]. Exposure to biomass smoke has been linked to increased oxidative stress in ocular tissues, potentially accelerating cataract formation [10].

Visual impairment disorder such as cataract, glaucoma, or pterygium, has serious consequences for the quality of life and ability to work, and it can lead to other health problems [12,13]. Eye complaints, including eye pain, blurred vision, redness, and tears, are associated with exposure to smoke from cooking are common phenomenon among biomass fuel users [8-10,14]. These complaints are often the sign of commencement of the disorders. There is also evidence to link ambient air pollutants (AAP) with the above eye-related disease [10, 15,16]. Biomass smoke condensate, like that of tobacco smoke, is known to produce superoxide radicals that may increase the risk of cataracts [10,15,17,18]. However, the exact mechanism by which pollutants cause eye disorders remains elusive and may vary depending on the type of disease/disorder [10,11]. It has been hypothesized that women are at greater risk of visual impairment arising from the use of biomass fuels, because of their greater exposure to smoke while cooking [19]. According to a study by Li, et al [20], the use of biomass fuel for cooking was associated with greater eye disorder and hypertension risk, especially among the aged. Several studies have reported a significant positive association between biomass fuel use and ocular impairment, including cataract, glaucoma, poor visual acuity, and even blindness [21-23].

Despite the widespread use of biomass fuels in Nigeria, epidemiological evidence linking biomass exposure to ocular health outcomes remains limited. This study therefore assessed the association between biomass cooking fuel use and the prevalence of visual defects among household members in Enugu State, Nigeria, with a view to addressing a critical knowledge gap and to inform public health interventions.

2. Materials and methods

Study design and setting: A community-based cross-sectional study was conducted in six LGAs across the three senatorial districts of Enugu State, Nigeria.

Study population: The study included household members aged 14–70 years who had resided in the study area for at least one year. A total of 502 respondents from 232 households participated.

Sampling technique: A multistage sampling technique was employed. LGAs were stratified by senatorial district, with two LGAs selected from each district using simple random sampling. Wards, settlements, and households were subsequently selected using random and systematic sampling methods.

Data collection: Data were collected using a structured questionnaire capturing socio-demographic characteristics, cooking fuel type, and cooking practices. Visual acuity was assessed using a Snellen chart, and ocular examinations were conducted by an ophthalmologist to identify cataract, glaucoma, and pterygium.

Statistical analysis: Data collected, were analyzed using SPSS version 21. Descriptive statistics were used to summarize variables. Associations between cooking fuel type and visual defects were assessed using chi-square tests. Odds ratios (OR) with 95% confidence intervals (CI) were calculated, with significance set at $p < 0.05$.

Ethical considerations: The study protocol was approved by the Ethics and Research Committee of Abia University Teaching Hospital (ABSUTH/MAC/117/Vol.1/61). Written informed consent was obtained from all participants. Confidentiality was strictly maintained.

3. Results

Socio-demographic characteristics: A total of 502 respondents from 232 households across six LGAs participated. The majority lived in rural areas (374/502; 75%) and were female (356/502; 71%). The largest age group was 34–43 years (143/502; 28%). Farmers represented 32% of respondents, and secondary education was the most common educational level (240/502; 48%) (Table 2).

Cooking fuel usage: Biomass fuels were used by 94% (473/502) of respondents, with firewood (364/502; 72%) as the most common, followed by charcoal (103/502; 21%) and sawdust (54/502; 11%). Non-biomass fuels, such as LPG and kerosene, were used by just 6% (29/502) of respondents (Figure 1).

Prevalence of visual defects: Visual defects—including cataract, glaucoma, and pterygium—were predominantly observed among biomass users. Firewood users had the highest prevalence (154/364; 32.6%), followed by charcoal users (52/103; 11.4%). Sawdust users and fossil fuel users had minimal or no visual defects (Table 3 and Table 4).

Association between fuel type and visual defects: A Chi-square test indicated a significant association between biomass fuel use and visual defects (χ^2 = 112.3, p < 0.001). Firewood users had significantly higher odds of visual defects compared with non-biomass users (OR = 17.5; 95% CI: 9.8–31.2), while charcoal users had moderately increased odds (OR = 3.1; 95% CI: 1.7–5.6). No cases were observed among sawdust users, precluding OR calculation (Table 3).

Stratification by gender and age: Female firewood users had higher prevalence of visual defects (121/256; 47%) compared with male users (33/108; 31%). Prevalence increased with age, particularly among respondents older than 44 years. Farmers and traders, with greater cooking exposure, exhibited higher rates of visual defects.

Table 1 Number of respondents and households assessed in the study

Senatorial district	LGA sampled	Number of electoral wards visited	Number of settlements visited
Enugu-East	Enugu East	3	9
	Isi-Uzo	3	9
Enugu-North	Igboeze South	3	9
	Nsukka	2	5
Enugu-West	Aninri	3	9
	Awgu	2	4
Total		16	45

Table 1 above reflects data from the six LGAs sampled across three senatorial districts of Enugu State. Each LGA includes the number of wards, settlements, and households visited, along with the number of respondents assessed.

Table 2 Social-demographic characteristics of respondents across LGAs in Enugu State (n = 502)

Variables	Category	Aninri	Awgu	Enugu-East	Igboeze South	Isi-Uzo	Nsukka	Total (*n*, %)
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%)
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%)

Age (years)	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%)
	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 (16%)
	>63	3 (1%)	0 (0%)	2 (1%)	0 (0%)	0 (0%)	0 (0%)	5 (1%)
Occupation	Farmer	53 (11%)	15 (3%)	14 (3%)	24 (5%)	29 (6%)	28 (6%)	163 (32%)
	Trader	17 (3%)	5 (1%)	52 (10%)	32 (6%)	17 (3%)	20 (5%)	143 (28%)
	Artisan	3 (1%)	5 (1%)	34 (7%)	14 (3%)	4 (1%)	4 (1%)	64 (13%)
	Civil Servant	2 (1%)	8 (2%)	16 (3%)	4 (1%)	11 (2%)	8 (2%)	49 (10%)
	Student	5 (1%)	7 (1%)	22 (4%)	26 (5%)	19 (4%)	4 (1%)	83 (17%)
Educational/ Literacy level	No formal education	24 (5%)	3 (1%)	8 (2%)	14 (3%)	6 (1%)	20 (5%)	75 (15%)
	Primary	29 (6%)	12 (2%)	30 (6%)	24 (5%)	21 (4%)	12 (2%)	128 (25%)
	Secondary	24 (5%)	20 (4%)	70 (14%)	58 (12%)	48 (10%)	20 (5%)	240 (48%)
	Tertiary	3 (1%)	5 (1%)	30 (6%)	4 (1%)	5 (1%)	12 (2%)	59 (12%)

Table 2 above presents demographic distribution by LGA for social setting, gender, age, occupation, and educational level. Percentages were calculated relative to the total respondents (*n* = 502).

Table 3 Incidences of visual defects among biomass users (*n* = 473)

Fuel type	Total users	Visual defects* (*n*, %)	Odds ratio (OR) vs non-biomass	95% CI	p-value
Firewood	364	154 (32.6%)	17.5	9.8–31.2	<0.001
Charcoal	103	52 (11.4%)	3.1	1.7–5.6	<0.001
Sawdust	54	0 (0%)	–	–	–

*Cataract, glaucoma, and pterygium

Table 4 Incidences of visual defects among non-biomass users (*n* = 29)

Fuel type	**Total users**	**Visual defects (*n*, %)**
LPG	0	0 (0%)
Kerosene	29	0 (0%)

There was no case of visual defect among LPG and kerosene users.

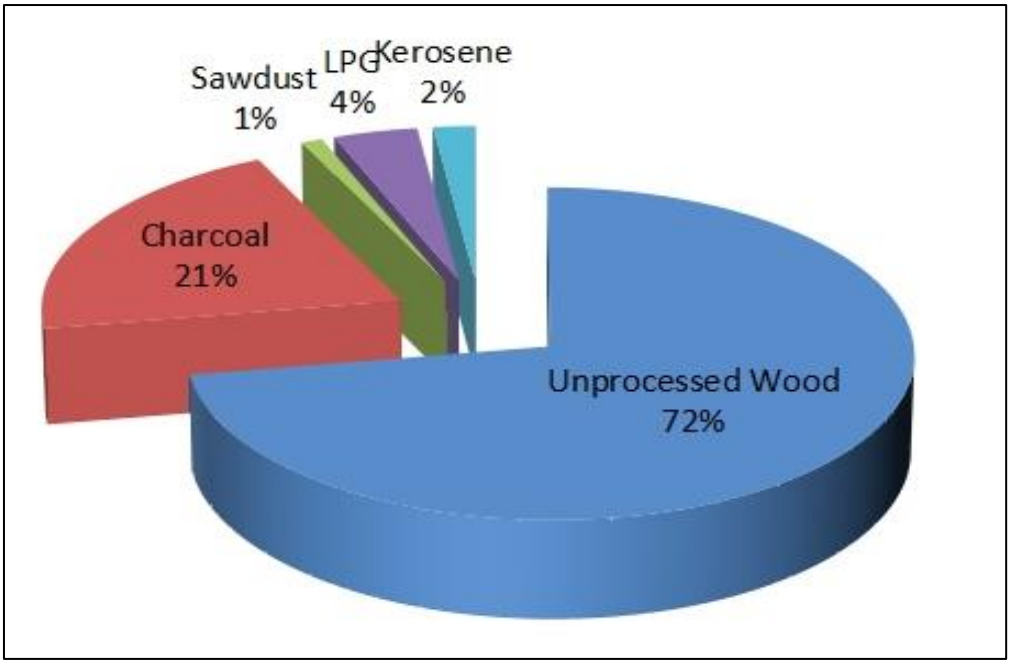

Figure 1 Primary cooking fuels used by the respondents

This shows that greater proportion of the respondents (364/502, 72%) uses unprocessed wood as cooking fuel, followed by 21% (103/502) who use charcoal. Only a small proportion (4% and 2%) of the respondents were recorded to use LPG and kerosene respectively.

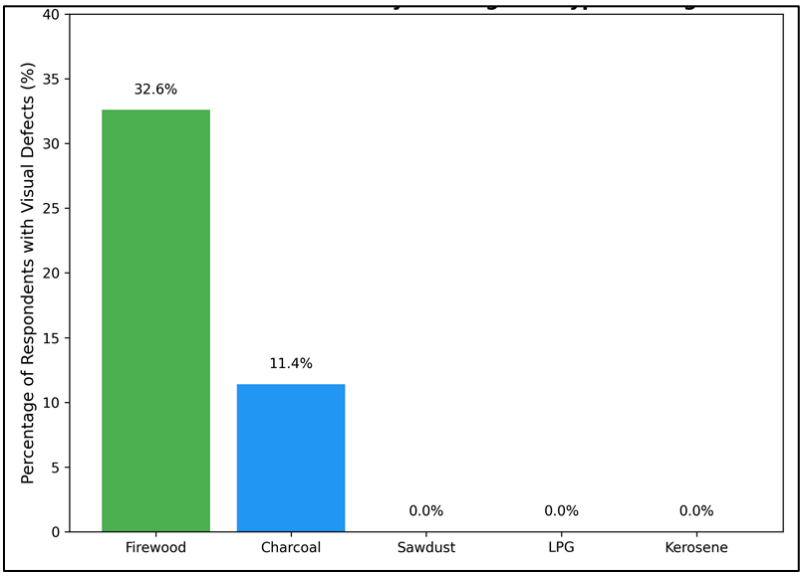

Figure 2 Prevalence of visual defects among households across all cooking fuel users

Bar chart showing the prevalence of visual defects (cataract, glaucoma, or pterygium) among users of different cooking fuels in Enugu State. Firewood users exhibited the highest prevalence (32.6%), followed by charcoal users (11.4%). No visual defects were observed among sawdust, LPG, or kerosene users. Statistical significance was confirmed via Chi-square test ($\chi^2 = 112.3$, $p < 0.001$). Odds ratios and 95% confidence intervals are included for biomass fuel users relative to non-biomass users.

4. Discussion

Air pollution from household fuel combustion is a serious global environmental health risk, according to the World Health Organization [24]. Nearly 3 billion of the world's poorest people continue to rely on solid fuels (such as wood, animal dung, charcoal, crop wastes, and coal) burned in inefficient and polluting stoves for cooking and heating. This results in approximately 4 million premature deaths each year among children and adults from respiratory and cardiovascular diseases, as well as cancer. The negative health effects of biomass fuel combustion in households cannot be overemphasized. Biomass smoke contains numerous harmful substances, including carbon monoxide, formaldehyde, acrolein, benzene, nitrogen dioxide, ozone, and particulate matter. Fine particles less than 10 microns in diameter (PM_{10}) are among the most dangerous. These pollutants are known to cause respiratory diseases, eye problems, and other illnesses [24, 25].

The results of this study demonstrated a significant association between biomass cooking fuel use and the prevalence of visual defects among household members in Enugu State. Firewood users exhibited the highest prevalence of cataract, glaucoma, and pterygium (32.6%), followed by charcoal users (11.4%), whereas sawdust and non-biomass fuel users recorded minimal or no visual defects. These findings suggest that incomplete combustion and higher smoke emission from unprocessed firewood substantially increase ocular health risks, consistent with earlier reports [26].

Biomass smoke contains carbon monoxide, particulate matter, formaldehyde, and oxidant gases capable of inducing oxidative stress in ocular tissues [8,10,24]. The underlying mechanism resembles that of tobacco smoke exposure, where oxidative damage contributes to cataract formation. The higher prevalence observed among females is likely attributable to prolonged exposure during cooking activities, in agreement with previous studies [19]. The observed exposure gradient—highest for firewood, moderate for charcoal, and minimal for sawdust—highlights the importance of fuel type and combustion efficiency.

Although the cross-sectional design limits causal inference and recall bias may have influenced self-reported data, this study provides important epidemiological evidence linking household biomass fuel use with ocular morbidity in a Nigerian population. Longitudinal studies are recommended to further elucidate causal relationships and assess intervention effectiveness.

5. Conclusion

The findings of the study show that the use of biomass cooking fuels, particularly unprocessed firewood, is associated with a high incidence of vision-disruptive disorders in Enugu State, Nigeria. Public health strategies should therefore prioritize the adoption of cleaner fuels, improved stove designs, and reforestation programs to ensure both environmental sustainability and ocular health protection. Interventions promoting cleaner cooking fuels, improved stove technologies, and awareness of ocular health risks are urgently needed.

Compliance with ethical standards

Disclosure of conflict of interest

There is no conflict of interest whatsoever, in this research work.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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