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Assessing the Prevalence of Smoke Exposure Risk (SER) Emanating from Household Cooking Practices in North-Western States of Nigeria

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ABSTRACT

Smoke exposure risk (SER) is a significant public health concern in North-Western Nigeria, where the use of biomass fuels for cooking remains widespread. These traditional fuels contribute to indoor air pollution, posing serious health risks, particularly for women and children. This study assesses the prevalence of SER and identifies the sociodemographic factors associated with SER in the north-western region , using data from the 2018 Nigeria Demographic and Health Survey (NDHS). A cross-sectional analysis was conducted on 9,506 households from the seven states of North-Western Nigeria. SER was classified based on the type of cooking fuel used and the location of cooking. Descriptive statistics were used to determine the prevalence of SER, and chi-square tests were employed to explore the relationships between SER and household characteristics, including household size, age, education level of the household head, wealth status, and residence. The analysis revealed that 68.24% of households were categorized as having medium SER, while 27.48% were classified under high SER. Significant associations were found between high SER and larger household size ($p < 0.001$), lower educational attainment ($p < 0.001$), poorer wealth status ($p < 0.001$), and rural residence ($p < 0.001$). State-level variations in SER were also observed, with Sokoto and Kano having the highest levels of exposure. This study underscores the urgent need for targeted interventions to reduce SER, particularly in rural and economically disadvantaged households in North-Western Nigeria, by increasing access to clean cooking technologies and enhancing public awareness.

Keywords: Smoke Exposure Risk, Biomass Fuels, Household Air Pollution, Clean Cooking Technologies, Demographic and Health Survey, NDHS

INTRODUCTION

Exposure to smoke from solid fuels is a major public health issue, particularly in low- and middle-income countries where traditional biomass fuels such as wood, charcoal, and animal dung are commonly used for cooking (Popoola & Ibrahim, 2023). These fuels release harmful pollutants, including particulate matter, carbon monoxide, and volatile organic compounds, which are known to increase the risk of respiratory and cardiovascular diseases, as well as contribute to environmental degradation (Balmes, 2019). Globally, it is estimated that about 3.8 million premature deaths annually are attributable to household air pollution caused by the burning of solid fuels, with women and children disproportionately affected due to their roles in cooking and spending more time indoors (Mohajeri et al., 2023).

In Nigeria, the reliance on biomass fuels remains prevalent, especially in rural areas where access to clean cooking alternatives is

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limited ((WHO, 2020) *Household Air Pollution*, n.d.). The North-Western region of Nigeria is particularly vulnerable, characterized by high poverty levels, low literacy rates, and a predominantly rural population. These socio-economic conditions contribute to the continued dependence on traditional cooking methods, which pose significant smoke exposure risks (SER) (Sani et al., 2024). The 2018 Nigeria Demographic and Health Survey (NDHS) reported that a substantial proportion of households in this region rely on solid fuels for cooking, with limited adoption of cleaner alternatives like liquefied petroleum gas (LPG) or electricity (Gould & Urpelainen, 2018).

In Nigeria, the reliance on biomass fuels for cooking remains prevalent, especially in rural areas where access to clean cooking alternatives is limited (WHO, 2020). The North-Western region of Nigeria, characterized with serious socioeconomic issues and a predominantly rural population, faces significant challenges in adopting cleaner cooking fuels (Buba et al., 2017). These challenges, coupled with socio-economic factors, contribute to the continued reliance on traditional cooking methods, which pose significant smoke exposure risks (SER) (Ugwoke et al., 2020). The 2018 Nigeria Demographic and Health Survey (NDHS) reported that a substantial proportion of households in this region rely on solid fuels for cooking, with limited adoption of cleaner alternatives like liquefied petroleum gas (LPG) or electricity (National Population Commission [NPC] & ICF, 2019) Commission, 2019).

The health implications of SER are severe, with studies linking it to various adverse health outcomes, including acute lower respiratory infections in children, chronic obstructive pulmonary disease (COPD), and cardiovascular conditions (Mocumbi et al., 2019). The use of unclean fuels indoors exacerbates these risks, as poor ventilation in many homes further increases the concentration of harmful pollutants (Balmes, 2019). Despite these risks, there has been limited progress in reducing SER in North-Western Nigeria, partly due to socio-economic barriers and inadequate public health interventions (Ahmed et al., 2019).

This study aims to address the gap in understanding the prevalence and distribution of SER among households in North-Western Nigeria, utilizing data from the 2018 NDHS. The objectives of the research are threefold: (1) to assess the overall prevalence of SER in the region; (2) to examine the distribution of SER across the seven states within North-Western Nigeria; and (3) to identify the sociodemographic factors associated with SER, including household size, age, education level of the household head, wealth status, and urban or rural residence. The findings from this study will contribute to the existing literature by providing detailed insights into the factors driving SER in this region, thereby informing targeted public health interventions and policies aimed at reducing SER and its associated health burdens.

MATERIALS AND METHODS

Study Setting

The study was conducted across the seven northwestern states of Nigeria: Kebbi, Sokoto, Zamfara, Katsina, Kano, Jigawa, and Kaduna. These states are known for their predominantly rural populations and high rates of biomass fuel use for cooking, making them particularly vulnerable to household air pollution ().

Data Source and Study Sample

This study used data from the 2018 Nigeria Demographic and Health Survey (NDHS) to examine smoke exposure risk (SER) among households in North-western Nigeria focusing on the household recode (HR) file. The NDHS is a nationwide survey that collects information about households, including their demographics, socioeconomic status, and health. Only

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households that provided details about their cooking fuel and location were included in this analysis. After cleaning and checking the data, the final sample consisted of 9,506 households.

Study Variables

Dependent Variable: The smoke exposure risk (SER) variable was derived from two primary factors, following the methodology outlined by Ahamad & Tanin (2021):

Type of Cooking Fuel:

Clean Fuels: Electricity, LPG, natural gas, and biogas were categorized as clean fuels due to their lower emissions.

Unclean Fuels: Kerosene, coal, charcoal, wood, biomass fuels, and animal dung were categorized as unclean fuels due to their higher emissions.

Cooking Location

Outdoors: Cooking in an outdoor setting or in a separate building.

Indoors: Cooking inside the house.

The SER variable was created by combining these two factors into four ordinal categories:

Very Low SER: Clean cooking fuel and outdoors

Low SER: Clean cooking fuel and indoors

Medium SER: Unclean cooking fuel and outdoors

High SER: Unclean cooking fuel and indoors

This classification allows for the analysis and estimation of smoke exposure risk and the factors influencing it among Nigerian households.

Independent Variables: This study focused on various household characteristics as independent variables, which encompass the age and educational attainment of the household head, the wealth index, type of residence, sex of the household head, total number of household members, and the state of residence. These variables were examined to evaluate their impact on the risk of smoke exposure among Nigerian households.

Data Analysis

Descriptive statistics, including frequencies and proportions, were used to describe the study population and analyse the distribution of smoke exposure risk (SER). Cross-tabulations were employed to explore the relationships between SER and various household characteristics. Bar charts and pie charts were generated to visualize regional differences and the prevalence of SER across the north-western states of Nigeria. The association between household characteristics and SER was assessed using chi-square tests through cross-tabulation.

The data analysis was carried out using STATA version 15, taking into account the sampling weights to address the complex survey design of the Nigeria Demographic and Health Survey (NDHS) dataset.

Sociodemographic Characteristics of Households

A total of 9,506 households from the North-Western region of Nigeria were included in the analysis. The majority of households were located in rural areas (71.11%), and 92.29% were headed by males. Household sizes varied, with 36.45% comprising 4-6 members, followed by 25.97% with 1-3 members, 21.44% with 7-9 members, and 16.14% with 10 or more members. The age distribution of household heads showed that 36.67% were aged between 35-49 years, 24.57% were 25-34 years old, 22.36% were 50-64 years old, 12.01% were 65 years and above, and 4.39% were between 14-24 years old. Educational attainment was notably low, with 52.70% of household heads having no formal education, 17.26% with primary education, 18.11% with secondary education, and 11.92% with higher education. Regarding the wealth index, 32.74% of households were in the poorest quintile, 29.59% in the poorer quintile, 18.05% in the

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middle quintile, 10.88% in the richer quintile, and 8.75% in the richest quintile. The distribution of households across the seven states was as follows: Sokoto (8.76%), Zamfara (10.74%), Katsina (18.10%), Jigawa (11.45%), Kano (21.53%), Kaduna (19.85%), and Kebbi (9.58%).

Table 1: Sociodemographic Characteristics of Household (N = 9506).

Variable	Weighted Freq.	Percent
Household size of hh		
1-3	2469	25.97
4-6	3465	36.45
7-9	2038	21.44
10+	1534	16.14
Age of hh		
14-24	417	4.39
25-34	2336	24.57
35-49	3486	36.67
50-64	2125	22.36
65+	1142	12.01
Residence of hh		
Urban	2746	28.89
Rural	6760	71.11
Gender of hh		
Male	8774	92.29
Female	733	7.71
Wealth index hh		
Poorest	3112	32.74
Poorer	2813	29.59
Middle	1716	18.05
Richer	1034	10.88
Richest	832	8.75
Education level of hh		
No Education	5009	52.7
Primary	1640	17.26
Secondary	1722	18.11
Higher	1134	11.92
State		
Sokoto	833	8.76
Zamfara	1021	10.74
Katsina	1720	18.1
Jigawa	1088	11.45
Kano	2047	21.53
Kaduna	1887	19.85
Kebbi	910	9.58

*hh: head of household

Source: NDHS, 2008

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Prevalence and Distribution of Smoke Exposure by States

The analysis revealed a significant prevalence of high smoke exposure risk (SER) among households in North-Western Nigeria (Figure 1). Out of the 9,506 households, a considerable proportion were exposed to medium and high SER levels. Specifically, 68.24% of households were classified under medium SER, characterized by the use of unclean cooking fuel outdoors. Furthermore, 27.48% of households fell into the high SER category, where unclean fuels were used indoors, exacerbating the exposure to harmful smoke.

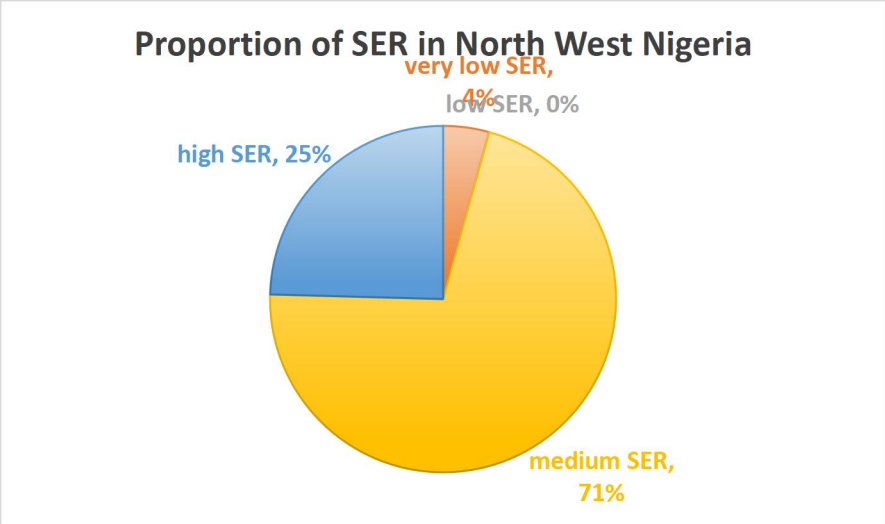

Figure 1: SER Prevalence in NW Nigeria.

Source: NDHS, 2008

The distribution of SER varied significantly across the seven states within the North-Western region (Figure 2, Figure 3). Kano had the highest proportion of households in the medium SER category (87.38%), while Sokoto had the highest proportion of households in the high SER category (51.89%). In contrast, Kebbi and Zamfara exhibited lower proportions of households with high SER at 36.17% and 19.83%, respectively. The variations across states underscore the heterogeneous nature of SER in the region.

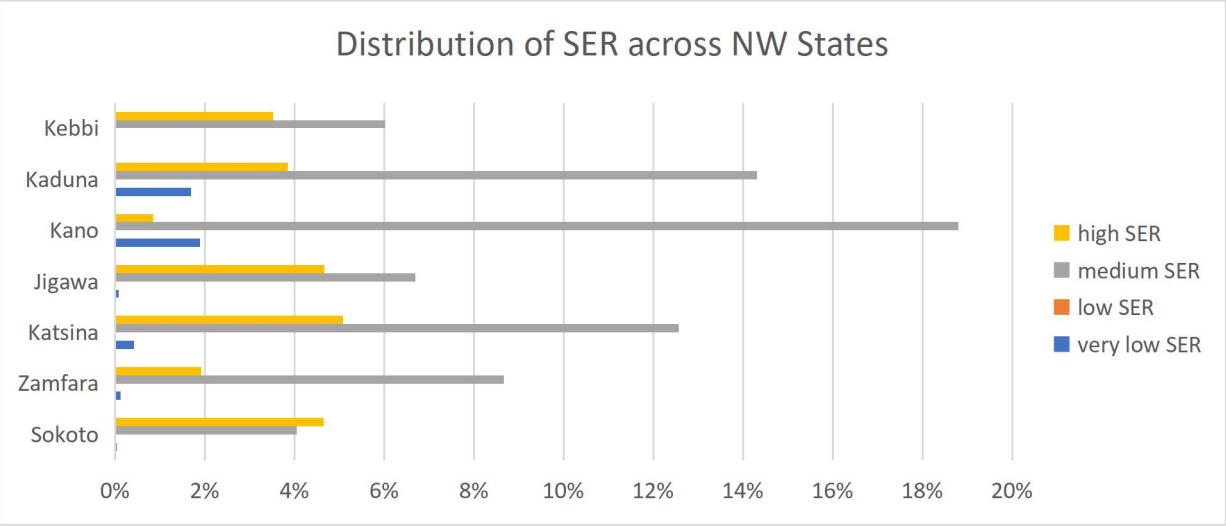

Figure 2: SER Distribution by States.

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Source: NDHS, 2008

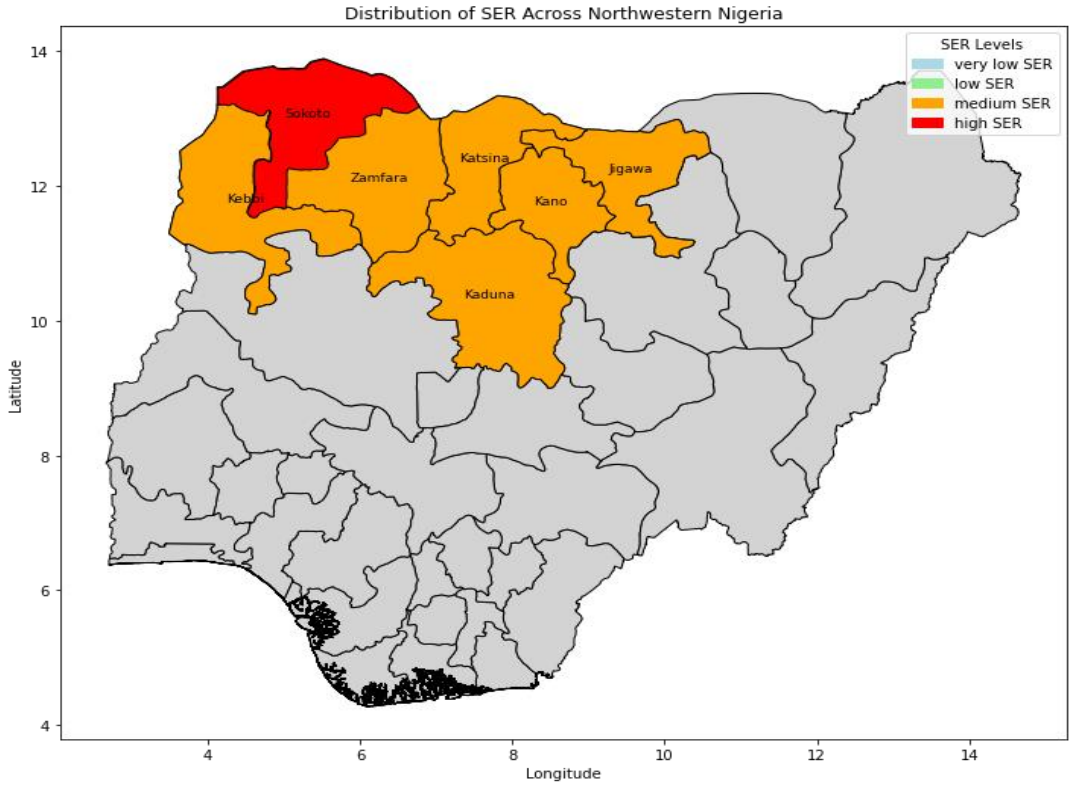

Figure 3: Map of Nigeria showing the prevalence of SER across the NW state

Source: Adapted from administrative Map of Nigeria

Factors Associated with Smoke Exposure Risk among Households

The study found that several household characteristics were significantly associated with SER levels (Table 2). Larger households were more likely to experience medium and high SER, with 68.25% of households with 1-3 members and 68.17% with 4-6 members falling into the medium SER category. A significant proportion of households with 7-9 members (28.22%) and 10+ members (21.42%) were also classified under high SER ($\chi^2 = 41.32$, $p < 0.001$). The age of the household head was another significant factor, with those aged 35-49 years showing the highest proportion of high SER (25.77%). Younger (14-24 years) and older (65+ years) household heads also exhibited elevated SER levels, reinforcing the vulnerability of these age groups ($\chi^2 = 35.97$, $p < 0.001$).

The study found that rural households had a significantly higher prevalence of high SER (30.65%) compared to urban households (16.49%) ($\chi^2 = 30.06$, $p < 0.001$). Female-headed households were also more vulnerable, with a higher proportion of high SER (19.13%) compared to male-headed households (27.34%) ($\chi^2 = 30.06$, $p < 0.001$). Wealth status was inversely related to SER; households in the poorest wealth quintile were significantly more likely to experience high SER (35.61%), while those in the richest quintile had the lowest risk (4.87%) ($\chi^2 = 2900.00$, $p < 0.001$). Educational attainment was similarly associated with SER, as households with no education had a high SER proportion of 32.07%, whereas those with higher education had the lowest (9.62%) ($\chi^2 = 1200.00$, $p < 0.001$). Additionally, significant differences in SER were observed across states, with Sokoto having the highest proportion of high SER

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(51.89%) and Kano exhibiting the highest medium SER (87.38%) (χ^2 = 1200.00, p < 0.001).

Table 2: Household Factors Associated with SER

Variable	Smoke Exposure Risk				X^2	P-Value
	Very Low SER	Low SER	Medium SER	High SER		
household members						
1-3	90 (4.44%)	1 (0.05%)	1,382 (68.25%)	552 (27.26%)		
4-6	115 (4.01%)	1 (0.03%)	1,953 (68.17%)	796 (27.78%)	41.32	0.00
7-9	45 (2.70%)	0 (0.00%)	1,153 (69.08%)	471 (28.22%)		
10+	30 (2.37%)	0 (0.00%)	964 (76.21%)	271 (21.42%)		
age of hh						
14-24	4 (1.22%)	0 (0.00%)	242 (74.01%)	81 (24.77%)		
25-34	48 (2.52%)	1 (0.05%)	1,321 (69.27%)	537 (28.16%)		
35-49	116 (4.11%)	0 (0.00%)	1,981 (70.12%)	728 (25.77%)	35.97	0.00
50-64	90 (4.96%)	0 (0.00%)	1,246 (68.61%)	480 (26.43%)		
65+	22 (2.32%)	1 (0.11%)	662 (69.76%)	264 (27.82%)		
residence						
Urban	261 (11.99%)	1 (0.05%)	1,556 (71.47%)	359 (16.49%)	30.06	0.00
Rural	19 (0.34%)	1 (0.02%)	3,896 (68.99%)	1,731 (30.65%)		
sex of hh						
Male	242 (3.35%)	2 (0.03%)	5,004 (69.28%)	1,975 (27.34%)	30.06	0.00
Female	38 (6.32%)	0 (0.00%)	448 (74.54%)	115 (19.13%)		
wealth index						
Poorest	0 (0.00%)	0 (0.00%)	1,806 (64.39%)	999 (35.61%)		
Poorer	2 (0.09%)	2 (0.09%)	1,589 (70.15%)	672 (29.67%)		
Middle	8 (0.60%)	0 (0.00%)	1,061 (79.00%)	274 (20.40%)	2900.00	0.00
Richer	24 (2.94%)	0 (0.00%)	675 (82.82%)	116 (14.23%)		
Richest	246 (41.28%)	0 (0.00%)	321 (53.86%)	29 (4.87%)		
educational level of hh						
No Education	13 (0.30%)	1 (0.02%)	2,905 (67.61%)	1,378 (32.07%)		
Primary	17 (1.32%)	0 (0.00%)	955 (74.15%)	316 (24.53%)	1200.00	0.00
Secondary	49 (3.70%)	1 (0.08%)	965 (72.94%)	308 (23.28%)		
Higher	201 (21.97%)	0 (0.00%)	626 (68.42%)	88 (9.62%)		
State						
Sokoto	5 (0.52%)	0 (0.00%)	454 (47.59%)	495 (51.89%)		
Zamfara	9 (0.96%)	1 (0.11%)	742 (79.10%)	186 (19.83%)		
Katsina	23 (2.08%)	1 (0.09%)	766 (69.13%)	318 (28.70%)		
Jigawa	7 (0.64%)	0 (0.00%)	635 (58.31%)	447 (41.05%)	1200.00	0.00
Kano	127 (8.52%)	0 (0.00%)	1,302 (87.38%)	61 (4.09%)		
Kaduna	105 (8.67%)	0 (0.00%)	897 (74.07%)	209 (17.26%)		
Kebbi	4 (0.39%)	0 (0.00%)	656 (63.44%)	374 (36.17%)		

Source: NDHS, 2008

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DISCUSSION

The results of this study reveal a critical public health concern regarding the prevalence of smoke exposure risk (SER) in North-Western Nigeria. The findings indicate that 68.24% of households in the region fall under the medium SER category, with 27.48% classified as having high SER, characterized by the use of unclean fuels indoors. These figures are consistent with previous studies that have highlighted the widespread use of biomass fuels in rural Nigerian households as a primary source of household air pollution (Buba et al., 2017; Onah et al., 2021).

The significant variation in SER across the seven states in the region underscores the complex interplay of socio-economic, cultural, and infrastructural factors that influence household fuel choices. For instance, Sokoto had the highest proportion of households experiencing high SER (51.89%), which may be attributed to the state's higher poverty rates and limited access to clean cooking alternatives (Popoola & Ibrahim, 2023). In contrast, Kano, which had the highest proportion of households with medium SER (87.38%), may benefit from relatively better economic conditions that enable some access to cleaner fuels, although traditional cooking practices remain prevalent (Buba et al., 2017; Sani et al., 2024).

The association between sociodemographic factors and SER is particularly noteworthy. Larger household sizes were significantly associated with higher SER, as seen in households with 7-9 members, where 28.22% were classified under high SER ($\chi^2 = 41.32$, $p < 0.001$). This finding suggests that larger families, due to higher energy demands, are more reliant on readily available, but unclean, biomass fuels (Roberman et al., 2021). Additionally, the age of the household head emerged as a critical factor, with households led by individuals aged 35-49 years showing the highest proportion of high SER (25.77%). This could reflect a generational adherence to traditional cooking practices, where older household heads may be less likely to adopt newer, cleaner technologies (Akeh et al., 2023; Ang'u, 2023).

The study also highlights the critical role of economic status in determining SER. Households in the poorest wealth quintile had the highest risk of smoke exposure, with 35.61% falling into the high SER category ($\chi^2 = 2900.00$, $p < 0.001$), while only 4.87% of the richest households faced similar risks. This disparity emphasizes the economic barriers that prevent poorer households from accessing cleaner cooking fuels like LPG (Ang'u, 2023; Sovacool, 2012). Educational attainment also plays a crucial role, as households with no formal education had a significantly higher SER compared to those with higher education levels ($\chi^2 = 1200.00$, $p < 0.001$). Educated household heads are likely more aware of the health risks associated with smoke exposure and the benefits of clean fuels, influencing their fuel choices (Gould & Urpelainen, 2020).

Moreover, the rural-urban divide in SER highlights infrastructural and accessibility challenges. Rural households, which make up the majority of the population in the study (71.11%), were more likely to experience high SER (30.65%) compared to urban households (16.49%) ($\chi^2 = 30.06$, $p < 0.001$). This finding is consistent with other research that points to the lack of infrastructure and market access in rural areas as major obstacles to the adoption of clean cooking technologies (Dongzagla & Adams, 2022).

CONCLUSION

This study highlights the significant smoke exposure risk (SER) faced by households in

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North-Western Nigeria, with notable disparities across states and sociodemographic groups. The findings emphasize the urgent need for targeted interventions that address the specific challenges of rural areas and economically disadvantaged households. By improving access to clean cooking technologies and raising awareness about the health risks of traditional fuels, public health outcomes in this region can be significantly improved. Focused efforts are required to reduce SER and protect vulnerable populations in North-Western Nigeria.

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