BMC Public Health

RESEARCH

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Understanding household smoke exposure risks (SER) in Nigeria: A regional analysis from the 2018 NDHS

Jamilu Sani[1*], Ismail Wali Garba[1], Abdulrazak Ahmed[2] and Mohamed Mustaf Ahmed[3]

Abstract

Background Indoor air pollution from household cooking fuels remains a pressing public health issue in low- and middle-income countries such as Nigeria. Reliance on solid fuels, including wood and charcoal, significantly contributes to respiratory diseases and premature mortality.

Methods This study utilized data from 39,725 households in the 2018 Nigeria Demographic and Health Survey (NDHS) to examine the prevalence and determinants of smoke exposure risk (SER). Multivariable ordinal regression was employed to investigate the associations between SER and household characteristics such as size, wealth, education, and regional disparities.

Results The findings indicate that 29% of households experienced high smoke exposure risk (SER), with significant disparities observed across regions. Households in the richest quintile were significantly less likely to face high SER, with an adjusted odds ratio (AOR) of 0.05 (95% CI: 0.04–0.06, $p < 0.001$), indicating a 95% reduction in odds, compared to the poorest quintile. Educational attainment further reduced SER, with households led by individuals with higher education exhibiting lower odds of high SER (AOR = 0.43, 95% CI: 0.38–0.49, $p < 0.001$), a 57% reduction in odds, compared to those headed by individuals with no formal education.

Conclusion This study underscores the importance of wealth and education in mitigating SER, and highlights the need for targeted interventions to address regional inequalities.

Keywords Smoke exposure risk, Household air pollution, Nigeria, Good health and well-being, Sustainable cities and communities, NDHS

*Correspondence:
Jamilu Sani
jamilu.sani@fubk.edu.ng
[1]Department of Demography and Social Statistics, Federal University Birnin Kebbi, Birnin Kebbi, Kebbi State, Nigeria
[2]Department of Geography and Environmental Management, Ahmadu Bello University, Zaria, Nigeria
[3]Faculty of Medicine and Health Sciences, SIMAD University, Mogadishu, Somalia

Background

In Nigeria, household air pollution from solid fuel use is a major contributor to respiratory illnesses and premature deaths, particularly in rural areas where reliance on biomass fuels remains high [1, 2]. Indoor air pollution from household cooking fuels represents a significant public health challenge, particularly in low- and middle-income countries (LMICs) such as Nigeria. In these regions, the widespread use of solid fuels, such as wood, charcoal, and animal dung, for cooking and heating has led to severe health implications. Globally, it is estimated that approximately 3 billion people rely on these solid fuels, contributing to nearly 4 million premature deaths annually due to household air pollution exposure [3, 4]. Sub-Saharan Africa, where energy poverty is rampant, faces a particularly high disease burden associated with this form of pollution [5]. The use of solid fuels remains prevalent in Nigeria, which is the most populous country in Africa, particularly in rural areas. According to the 2018 Nigeria Demographic and Health Survey (NDHS), a large proportion of households still depend on biomass fuels, despite the availability of cleaner alternatives, such as liquefied petroleum gas (LPG) and electricity [6]. This continued reliance on polluting fuels exacerbates the health burden, manifesting in conditions such as chronic obstructive pulmonary disease (COPD), acute respiratory infections in children, and cardiovascular diseases among adults [7].

The health risks associated with indoor air pollution are well documented. Exposure to smoke from solid fuels has been linked to several adverse health outcomes, including lower respiratory infections, lung cancer, and adverse pregnancy outcomes such as low birth weight [2, 8]. Women and children, who spend a considerable amount of time indoors and are often involved in cooking, are disproportionately affected [9]. The World Health Organization (WHO) has recognized household air pollution as one of the leading environmental risk factors contributing to death and disability in LMICs [1]. Household socioeconomic status plays a critical role in determining exposure to indoor air pollution. Studies in LMICs have shown that lower socioeconomic status is a significant predictor of household smoke exposure [5, 10–12] Economic constraints often limit access to cleaner fuels, increasing reliance on biomass and charcoal. Beyond wealth and education, factors such as cultural norms, access to clean fuel subsidies, and government policies play critical roles in shaping SER [13–15]. Wealthier households, which have the means to afford clean cooking technologies such as LPG and electric stoves, are better protected from the harmful effects of solid fuels [16]. In contrast, poorer households tend to rely on cheaper, yet more polluting fuels, thus exacerbating their exposure to harmful smoke [17]. Economic empowerment, therefore, has emerged as a key strategy for mitigating the health risks associated with indoor air pollution.

Education is another crucial determinant of household energy choice. Households headed by individuals with higher education levels are more likely to be aware of the health hazards posed by indoor smoke and are more inclined to adopt cleaner cooking practices [18]. Studies have shown that such households tend to use clean fuels and improve kitchen ventilation, thereby reducing exposure to indoor air pollutants [19]. Regional disparities in household energy use further complicate this issue. In Nigeria, access to clean energy sources varies significantly by region, with urbanization, infrastructure development, and economic conditions playing pivotal roles. According to previous studies, urban households are more likely to adopt clean energy solutions due to better access to infrastructure [11, 20, 21]" For example, the Southwest region, being more urbanized and economically developed, has greater access to clean cooking technologies and less reliance on solid fuels than the North-East and North-West regions, where poverty is more prevalent and modern energy services are scarce [20, 22].

Given these disparities, understanding the sociodemographic factors influencing smoke exposure risk (SER) across different regions of Nigeria is crucial. This study aimed to explore the prevalence and determinants of SER by using data from the 2018 NDHS. By examining household characteristics such as size, wealth, education, and region, this study seeks to identify the drivers of SER and provide evidence-based recommendations for reducing indoor air pollution in high-risk areas. The findings of this study are intended to contribute to the growing body of knowledge on the social determinants of health in LMICs, particularly in the context of environmental health risks. Identifying the key factors associated with SER will help in the design of targeted interventions to reduce the health burden of indoor air pollution in Nigeria. These interventions could include expanding access to clean cooking technologies, raising awareness about the health risks of indoor air pollution, and improving the energy infrastructure in underserved regions.

Methods

Study setting

The study was conducted across Nigeria, covering all six geopolitical regions: North-Central, North-East, North-West, South-East, South-South, and South-West. It includes households from both urban and rural settings, reflecting a wide variety of population densities.

Data source and study sample

This study utilized secondary data from the 2018 Nigeria Demographic and Health Survey (NDHS), focusing specifically on household record (HR) files. The NDHS

is a nationally representative survey that uses a stratified, multistage cluster sampling approach. Access to the NDHS dataset was obtained through an online application and an approval process. The analysis was centred on the Household Recode (HR) file, which contained demographic, socioeconomic, and health information for all members of the households. The analysis included only households that reported their primary cooking fuel and cooking location. After data cleaning and consistency checks, the final sample comprised 39,725 households with complete data on cooking fuel and location.

Study variables

This study examined the prevalence and determinants of SER in Nigerian households. The analysis focused on a dependent variable, SER, and a set of independent variables representing household characteristics. Cooking fuel was recoded into a binary variable: clean fuels (electricity, LPG, natural gas, biogas) as 1, and unclean fuels (kerosene, coal, charcoal, wood, biomass, animal dung) as 0. Similarly, cooking location was recoded as outdoor (1) or indoor (0). Consequently, the SER variable was constructed by combining these recoded variables, resulting in four ordinal categories: Very Low SER (clean fuel and outdoor cooking), Low SER (clean fuel and indoor cooking), Medium SER (unclean fuel and outdoor cooking), and High SER (unclean fuel and indoor cooking). This classification, which captures both the pollution source (fuel type) and the level of exposure (cooking location), providing a comprehensive risk assessment for household smoke exposure, follows the methodological framework outlined in previous DHS studies [23]. These prior studies established that smoke exposure risk is fundamentally influenced by both the pollution source and exposure concentration. By adopting this established framework, this study provides a robust assessment of household SER within the constraints of available DHS data.

Independent variables encompass a range of household characteristics that are hypothesized to influence SER. These include the age and education level of the household head, wealth index as a proxy for economic status, type of residence (urban or rural), sex of the household head, total number of household members, and geographical region. Categorical variables were appropriately controlled for in the analysis. These variables were selected to provide a comprehensive understanding of the sociodemographic and geographic factors that potentially contribute to variations in the smoke exposure risk among Nigerian households.

Table 1 Sociodemographic characteristics of household, $N = 39,725$

Variable	Frequency	Percentage
Sex of Household Head		
Male	32,471	81.74
Female	7,254	18.26
Wealth Index Combined		
Poorest	6,720	16.92
Poorer	7,302	18.38
Middle	8,096	20.38
Richer	8,585	21.61
Richest	9,022	22.71
Highest Educational Level		
No education, preschool	12,071	30.39
Primary	8,150	20.52
Secondary	12,779	32.17
Higher	6,692	16.85
Don't know	33	0.08
Residence		
Urban	18,692	47.05
Rural	21,033	52.95
Region		
North Central	5,566	14.01
North East	5,512	13.87
North West	9,507	23.93
South East	4,745	11.95
South South	5,712	14.38
South West	8,683	21.86
Members of Household		
Mean (SD)	4.7 (3.18)	
95% C.I.	4.62–4.68	
Age of Household Head		
Mean (SD)	45.7 (15.77)	
95% C.I.	45.59–45.90	

Data analysis

This study employed descriptive statistics, such as frequencies and proportions, to characterize the study population and assess the distribution of key variables. Cross-tabulations were used to investigate the relationship between smoke exposure risk (SER) and various household characteristics. To illustrate regional disparities and the prevalence of SER throughout Nigeria, bar and pie charts were created. To assess the household determinants of SER, multivariable ordinal regression analysis was conducted to identify the household factors linked to SER. Odds ratios with 95% confidence intervals were calculated, and statistical significance was assessed at the $p < 0.05$ level. Data analysis was carried out using STATA version 17. Sampling weights provided by NDHS were applied using STATA's svy command to adjust for complex survey design and ensure national representativeness.

Results

Sociodemographic characteristics of households

The study sample consisted of 39,725 households with a male-headed majority (81.74%). Table 1 presents the sociodemographic characteristics of the study

population. The wealth index distribution revealed that 22.71% of the households were in the richest quintile, while 16.92% were in the poorest quintile. Educational attainment showed that 32.17% of household heads had secondary education and 30.39% had no formal education. The majority of the households (52.95%) resided in rural areas. The regional distribution was most prominent in the northwest (23.93%) and least prominent in the southeast (11.95%). The average household size was 4.7 members (SD = 3.18), and the mean age of household heads was 45.7 years (SD = 15.77).

Prevalence of smoke exposure risk

The prevalence of SER varies significantly between regions (Figs. 1 and 2). Overall, 13% of households fell into the very low SER category, 1.61% into the low SER category, 55% into the medium SER category, and 29% into the high SER category. Households in the North-East and North-Central regions had the highest prevalence of high SER, exceeding 40%, while the South-West had the lowest prevalence of high SER, with over 35% classified under very low risk. Specifically, the Southwest region had the highest proportion of households with a very low SER (35.79%), while the Northeast had the lowest (1.67%). Conversely, high SER was most prevalent in the South-East (45.17%) and North-Central regions (40.40%).

Household factors associated with smoke exposure risk

Multivariable ordinal regression analysis identified several significant household characteristics that influence the levels of smoke exposure risk (SER) among Nigerian households (Table 2). Household size emerged as a factor, with larger households being more likely to fall into the medium and high SER categories. However, the effect size was modest (AOR = 1.01, 95% CI: 1.00-1.02, $p = 0.10$). The age of the household head did not show a significant relationship with SER levels, with the odds ratios across SER categories being very close to 1 (AOR = 1.00, 95% CI: 1.00–1.00, $p = 0.86$). This indicates that age alone does not substantially impact the smoke exposure risk. However, the sex of the household head was a significant factor, with female-headed households showing lower odds of high SER than those headed by males (AOR = 0.82, 95% CI: 0.77–0.89, $p < 0.001$).

Wealth is one of the most significant predictors of the SER. The analysis showed that households in the richest wealth quintile were markedly less likely to experience high SER compared to the poorest households

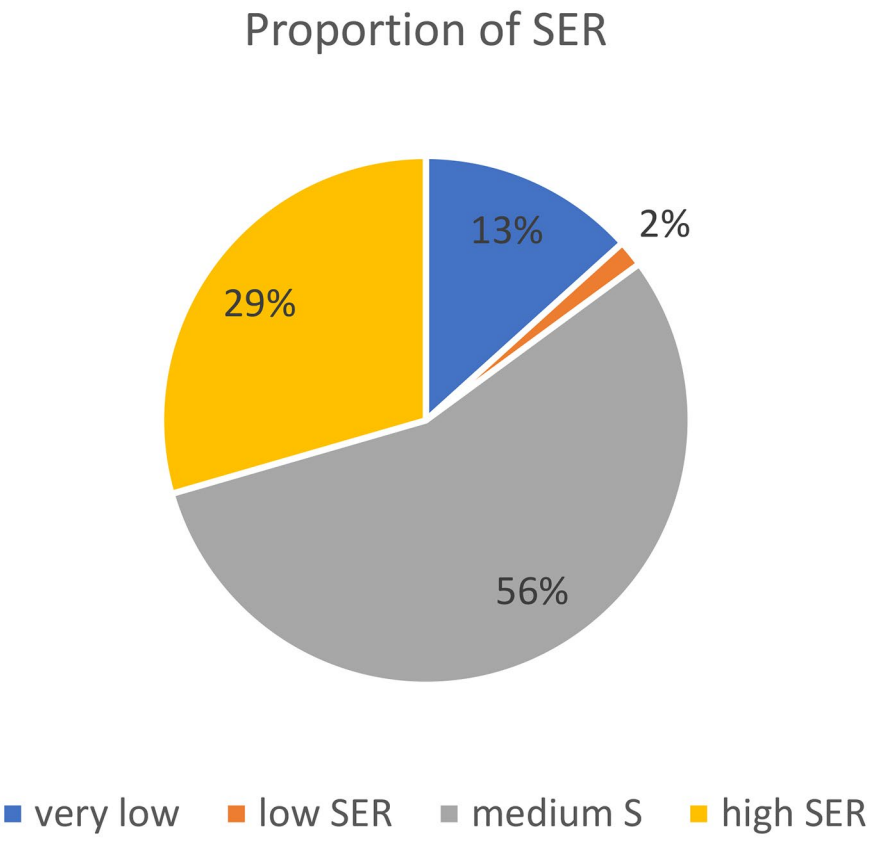

Fig. 1 Prevalence of SER in Nigeria

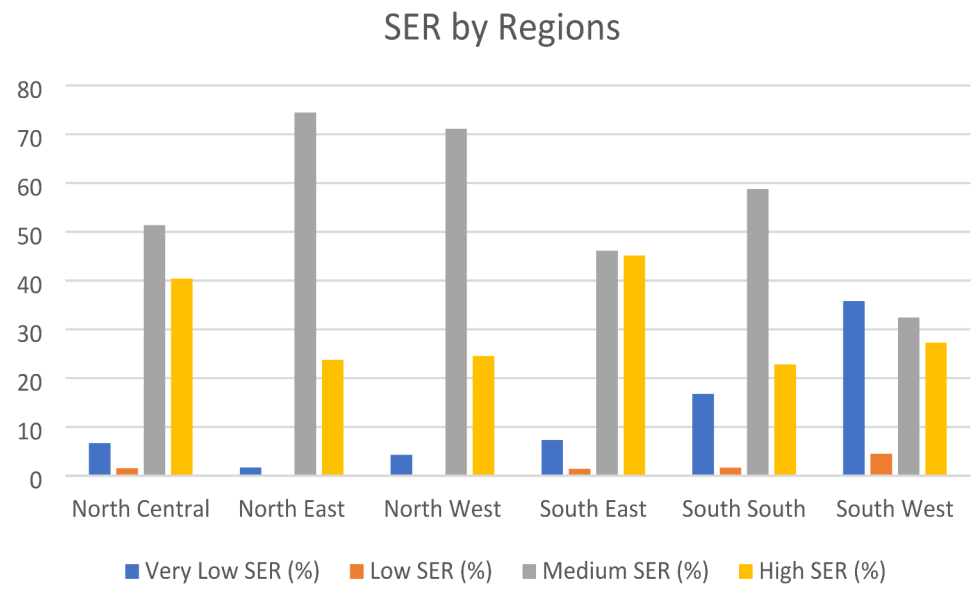

Fig. 2 Regional Prevalence of SER in Nigeria

(AOR = 0.05, 95% CI: 0.04–0.06, $p < 0.001$). This gradient was consistent across all wealth categories, with higher wealth correlating with lower SER. The educational attainment of the household head also played a crucial role in determining SER. Households with heads who had attained higher education levels were significantly less likely to fall into the high SER category (AOR = 0.43, 95% CI: 0.38–0.49, $p < 0.001$) than those with no formal education. The type of residence urban versus rural) also influenced SER, although the effect was relatively small and not statistically significant (AOR = 1.06, 95% CI: 0.93–1.20, $p = 0.40$). Rural households, which often rely on traditional, unclean fuels such as wood and charcoal owing to their availability and affordability, have a slightly higher risk of high SER. Regional differences in the SER were also pronounced. Households in the southwest region had significantly higher odds of very low SER compared to those in the north-central region, which was used as the reference category. Conversely, households in the northeast and northwest were more likely to experience medium and high SER, with lower odds of very low SER (AOR = 0.44, 95% CI: 0.38–0.50, $p < 0.001$ for the North-West). The Southeast region presented a complex picture, with households showing both higher odds of very low SER (AOR = 1.88, 95% CI: 1.57–2.24, $p < 0.001$) and high SER (45.17%).

Discussion

This study examined the household determinants of smoke exposure risk (SER) in Nigeria, revealing the significant influence of socioeconomic factors, gender, and regional disparities. The findings underscore the critical roles of household wealth and educational attainment in shaping SER while also highlighting persistent infrastructural challenges in certain regions. Unlike previous research that primarily categorizes household air pollution risk based on fuel type alone, this study utilized a four-category SER classification (Very Low, Low, Medium, and High), incorporating both fuel type and cooking location to provide a more comprehensive risk assessment [23].

A strong inverse relationship between wealth and SER was observed, with households in the richest quintile significantly less likely to experience high SER (AOR = 0.05, 95% CI: 0.04–0.06, $p < 0.001$) compared to the poorest quintile. This finding aligns with previous studies that suggest economic status plays a key role in determining household energy choices, as wealthier households can afford cleaner cooking fuels such as liquefied petroleum gas (LPG) and electricity, which significantly reduce indoor air pollution exposure [24]. Wealthier households are also more likely to reside in better-ventilated homes and have greater access to clean cooking technologies [5]. However, fluctuating LPG prices and supply chain inconsistencies in Nigeria may limit clean energy adoption even among financially capable households [20].

Educational attainment was also a significant predictor of SER, with households led by individuals with higher education being less likely to experience high SER (AOR = 0.43, 95% CI: 0.38–0.49, $p < 0.001$). Education increases awareness of the health risks of biomass fuel use and enhances the likelihood of adopting clean energy alternatives [10, 24]. In many LMICs, education plays a vital role in fuel transition decisions, as higher awareness and knowledge of health risks encourage behavioural changes in household energy use [11]. However,

Table 2 Ordinal regression of household factors associated with smoke exposure risk

Variable	Smoke Exposure Risk				AOR [95% C.I.]	*p*-value
	Very Low	Low SER	Medium SER	High SER		
Household Members						
Mean(SD)	3.6 (2.16)	3.0 (2.21)	5.0 (3.36)	4.6 (3.01)	1.01 [1.00, 1.02]	0.10
Age of Household Head						
Mean (SD)	43.8 (13.90)	37.2 (12.59)	46.2 (15.73)	46.2 (16.01)	1 [1.00, 1.00]	0.86
Sex of Head of Household						
male	4,290 (13.21%)	454 (1.40%)	18,298 (56.35%)	9,428 (29.04%)	R.C	
female	994 (13.71%)	190 (2.62%)	3,789 (52.24%)	2,281 (31.44%)	0.82 [0.77, 0.89]	0.00
Wealth Index						
poorest	4 (0.06%)	1 (0.02%)	4,274 (63.61%)	2,440 (36.31%)	R.C	
poorer	10 (0.14%)	4 (0.06%)	4,458 (61.04%)	2,830 (38.76%)	1.03 [0.92, 1.16]	0.58
middle	80 (0.99%)	19 (0.24%)	5,084 (62.80%)	2,913 (35.98%)	0.86 [0.75, 0.98]	0.02
richer	726 (8.46%)	196 (2.29%)	5,049 (58.81%)	2,613 (30.44%)	0.54 [0.45, 0.64]	0.00
richest	4,464 (49.48%)	423 (4.69%)	3,223 (35.72%)	913 (10.12%)	0.05 [0.04, 0.06]	0.00
Educational Level						
no education/ preschool	151 (1.25%)	36 (0.30%)	7,566 (62.67%)	4,319 (35.78%)	R.C	
primary	436 (5.35%)	96 (1.18%)	4,848 (59.49%)	2,770 (33.98%)	0.88 [0.81, 0.96]	0.00
secondary	2,036 (15.93%)	309 (2.42%)	6,794 (53.16%)	3,640 (28.48%)	0.82 [0.75, 0.90]	0.00
higher	2,657 (39.70%)	204 (3.04%)	2,864 (42.79%)	968 (14.46%)	0.43 [0.38, 0.49]	0.00
Residence						
urban	4,534 (24.26%)	527 (2.82%)	8,825 (47.22%)	4,805 (25.71%)	R.C	
rural	750 (3.57%)	117 (0.56%)	13,262 (63.05%)	6,904 (32.82%)	1.06 [0.93, 1.20]	0.40
Region						
north central	373 (6.69%)	85 (1.53%)	2,859 (51.36%)	2,249 (40.41%)	R.C	
north east	92 (1.67%)	6 (0.10%)	4,103 (74.45%)	1,310 (23.77%)	0.43 [0.36, 0.51]	0.00
north west	407 (4.28%)	2 (0.03%)	6,761 (71.12%)	2,336 (24.57%)	0.44 [0.38, 0.50]	0.00
south east	347 (7.31%)	66 (1.39%)	2,189 (46.13%)	2,143 (45.17%)	1.88 [1.57, 2.24]	0.00
south south	957 (16.75%)	94 (1.65%)	3,358 (58.79%)	1,303 (22.81%)	0.64 [0.53, 0.76]	0.00
south west	3,108 (35.80%)	391 (4.50%)	2,817 (32.44%)	2,367 (27.26%)	0.51 [0.40, 0.66]	0.00
Cut Points						
/cut3 (Low SER/Very Low SER)					-0.21 [-0.46, 0.03]	
/cut2 (Medium SER/Low SER)					-3.81 [-4.07, -3.55]	
/cut1 (High SER/Medium SER)					-4.02 [-4.27, -3.76]	

in Nigeria, education alone may not be sufficient to overcome structural barriers to clean energy adoption, as factors such as fuel affordability, distribution networks, and policy constraints still influence household decisions [14, 25].

Gender disparities in SER were evident, with female-headed households exhibiting lower exposure risk (AOR = 0.82, 95% CI: 0.77–0.89, $p < 0.001$). Studies have suggested that women, when financially empowered, tend to prioritize household health and cleaner fuel adoption [12, 26]. However, this relationship is complex, as other factors such as cultural norms, decision-making power, and economic constraints also shape women's energy choices [9]. Future research should explore the mechanisms through which gender influences SER, particularly in relation to energy security and fuel affordability.

Significant regional disparities in SER were observed, reinforcing structural inequalities in clean energy access across Nigeria. The North-East and North-Central regions exhibited the highest prevalence of High SER, likely due to low household incomes, inadequate clean energy infrastructure, and persistent reliance on biomass fuels [20, 27]. Additionally, ongoing conflict and insecurity in northern Nigeria may further exacerbate clean fuel accessibility issues, limiting household transitions to modern energy sources [22]. In contrast, households in the South-West had the highest prevalence of Very Low SER, reflecting higher urbanization rates and greater access to LPG and electricity [13]. The South-East region exhibited a mixed pattern, with some households experiencing low SER and others facing high SER, suggesting urban-rural disparities in clean energy adoption. These findings emphasize the need for regionally tailored interventions to address economic and infrastructural barriers to clean energy access [25, 28–30].

Given the strong association between wealth, education, and SER, addressing regional disparities requires targeted, multi-sectoral interventions. Expanding LPG subsidies could help mitigate financial barriers, particularly in high-SER regions such as the North-East and North-Central. However, findings indicate that economic constraints are not the only determinant of clean energy adoption; fuel availability and distribution challenges also contribute to high SER levels. As such, investments in LPG distribution networks, rural electrification, and improved cookstove technology remain essential to long-term energy transitions [16, 30, 31]. Additionally, promoting safer cooking environments, such as improved ventilation, outdoor cooking spaces, and clean stove adoption, could provide immediate health benefits in regions where shifting to cleaner fuels remains a challenge [13, 17, 29].

Findings also reveal that female-headed households exhibit lower SER, highlighting the potential role of gender-sensitive interventions in clean energy adoption. Policies should strengthen women's financial autonomy in energy decision-making, as financial constraints remain a significant barrier for many households. Providing microfinance opportunities for female entrepreneurs in clean cooking markets and ensuring women-led households receive priority access to clean energy subsidies could enhance adoption rates [5, 26, 32]. These recommendations align with Sustainable Development Goal (SDG) 3 (Good Health and Well-being) and SDG 7 (Affordable and Clean Energy), reinforcing the urgent need for integrated policies that combine clean energy access with broader poverty reduction and public health initiatives [28, 33, 34].

Conclusion

This study highlights the significant role of socioeconomic factors and regional disparities in shaping household smoke exposure risk (SER) in Nigeria. Wealthier and more educated households exhibited lower SER, reflecting better access to clean cooking fuels and awareness of indoor air pollution risks. However, stark regional disparities persist, particularly in the North-East and North-Central regions, where economic constraints and limited energy infrastructure hinder the transition to cleaner fuels. Addressing these disparities requires targeted, evidence-based interventions that combine economic incentives, education, and infrastructure improvements to ensure equitable energy access. These findings align with Sustainable Development Goals (SDG) 3 and 7, emphasizing the need for integrated, multi-sectoral action to promote cleaner household energy use and improve public health outcomes.

Limitation

This study has several limitations. Firstly, the estimation of smoke exposure risk (SER) relied on self-reported data from the Nigeria Demographic and Health Survey (NDHS), which may introduce recall bias, as participants may inaccurately recall cooking practices, and social desirability bias, as they may underreport the use of polluting fuels. These biases could lead to misclassification of households into SER categories, affecting prevalence estimates and associations with household characteristics. Secondly, while the analysis accounted for key socioeconomic determinants, it did not incorporate environmental factors such as ambient pollution and neighbourhood effects, limiting our ability to fully assess external contributions to household smoke exposure. This omission may result in an overestimation of household fuel use contribution to SER in urban areas, where external pollution sources are significant, while having a negligible impact in rural areas where household fuel is the primary pollution source. Future research should integrate geospatial data and air quality monitoring for a more comprehensive assessment of household and environmental pollution exposure. Thirdly, the cross-sectional nature of this study prevents causal inference. While associations between wealth, education, gender, and SER were identified, we cannot determine whether these factors directly influence SER or if unmeasured variables mediate these relationships. Additionally, this design does not capture long-term effects of economic and educational changes on household energy transitions. Future longitudinal studies should track household energy choices and smoke exposure patterns over time to establish stronger causal relationships and better understand fuel transition dynamics. Despite these limitations, this study provides a valuable regionally disaggregated analysis of SER in Nigeria, offering important insights for policymakers and public health stakeholders seeking to develop targeted interventions to reduce household air pollution exposure.

Acknowledgements

We thank the National Population Commission and ICF International for the 2018 NDHS data. We also acknowledge the contributions of the research team and the women who participated in the survey. Their support was crucial for this research.

Author contributions

JS conceptualized, designed, and conducted the study, including data analysis, visualization, resource gathering, data curation, and writing the original draft. MMA provided oversight, review, and editing. IGW and AA also contributed to the manuscript review and editing.

Funding

The authors have not received any funding for this study.

Data availability

The data supporting the findings of this study are available from the DHS Program and can be accessed through their website at https://dhsprogram.com/.

Declarations

Ethics approval and consent to participate
This study utilized data from the 2018 Nigeria Demographic and Health Survey (NDHS), which was conducted in accordance with the Helsinki Declaration. Ethical approval was obtained from the National Health Research Ethics Committee of Nigeria (NHREC) and the ICF Institutional Review Board. Informed consent was obtained from all participants prior to data collection. As this is a secondary data analysis, the researchers ensured confidentiality and anonymity in line with ethical guidelines.

Consent for publication
This study utilizes data from the Demographic and Health Surveys (DHS) Program, specifically the 2018 Nigeria Demographic and Health Survey dataset. No primary data collection was conducted for this research. As such, consent for data use is not applicable in the traditional sense, as individual participants' data were not collected or involved directly in this study.

Competing interests
The authors declare no competing interests.

Clinical trial number
Not applicable.

Received: 17 October 2024 / Accepted: 1 April 2025
Published online: 10 April 2025

References

1. Npc NPC. ICF. Nigeria Demographic and Health Survey 2018 - Final Report. 2019 Oct 1 [cited 2024 Aug 9]; Available from: https://dhsprogram.com/publications/publication-fr359-dhs-final-reports.cfm
2. Roberman J, Emeto TI, Adegboye OA. Adverse birth outcomes due to exposure to household air pollution from unclean cooking fuel among women of reproductive age in Nigeria. Int J Environ Res Public Health. 2021;18(2):634.
3. Household air pollution [Internet]. [cited 2024 Jul 29]. Available from: https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health
4. Household Air Pollution| UNDRR [Internet]. 2023 [cited 2025 Feb 9]. Available from: https://www.undrr.org/understanding-disaster-risk/terminology/hips/en0001
5. Balmes JR. Household air pollution from domestic combustion of solid fuels and health. J Allergy Clin Immunol. 2019;143(6):1979–87.
6. NPC & ICF. (2019). Nigeria Demographic and Health Survey 2018. National Population Commission and ICF. - Google Search [Internet]. [cited 2024 Jul 29]. Available from: https://www.google.com/search?q=NPC+%26+ICF.+(2019).+Nigeria+Demographic+and+Health+Survey+2018.+National+Population+Commission+and+ICF.%26;oq=NPC+%26+ICF.+(2019).+Nigeria+Demographic+and+Health+Survey+2018.+National+Population+Commission+and+ICF.%26;gs_lcrp=EgZjaHJvbWUyBggAEEUYOTIGCAEQRRg80gEIMTExN2owajeoAgiwAgE%26;sourceid=chrome%26;ie=UTF-8
7. Mocumbi AO, Stewart S, Patel S, Al-Delaimy WK. Cardiovascular effects of indoor air pollution from solid fuel: relevance to Sub-Saharan Africa. Curr Envir Health Rpt. 2019;6(3):116–26.
8. Ali MU, Yu Y, Yousaf B, Munir MAM, Ullah S, Zheng C, et al. Health impacts of indoor air pollution from household solid fuel on children and women. J Hazard Mater. 2021;416:126127.
9. Campbell CA, Bartington SE, Woolley KE, Pope FD, Thomas GN, Singh A, et al. Investigating cooking activity patterns and perceptions of air quality interventions among women in urban Rwanda. Int J Environ Res Public Health. 2021;18(11):5984.
10. Gould CF, Urpelainen J. The role of education and attitudes in cooking fuel choice: evidence from two States in India. Energy Sustain Dev. 2020;54:36–50.
11. Dongzagla A, Adams AM. Determinants of urban household choice of cooking fuel in Ghana: do socioeconomic and demographic factors matter? Energy. 2022;256:124613.
12. Kelkar G, Nathan D. Cultural and economic barriers in switching to clean cooking energy: does women's agency make a difference? Energies. 2021;14(21):7242.
13. Ozughalu UM. Patterns and determinants of households' energy choices for cooking as well as their implications for poverty eradication in Nigeria. J Developing Areas. 2023;57(4):175–99.
14. Popoola TO, Ibrahim S. Determinants of households' primary cooking fuel in Nigeria: evidence from country-wide study. Ilorin J Economic Policy. 2023;10(2):1–15.
15. Abila DB, Nalunkuma R, Wasukira SB, Ainembabazi P, Aggrey S, Kisuza RK et al. Trends in household air pollution contributed by the type of cooking fuel used in Ugandan households from 2000 to 2016 and associated household factors: An analysis of demographic and health surveys. Research Square [Internet]. 2021 [cited 2024 Aug 27]; Available from: https://eprints.gla.ac.uk/311420/
16. Malla S, Timilsina GR. Household cooking fuel choice and adoption of improved cookstoves in developing countries: a review. World Bank Policy Research Working Paper [Internet]. 2014 [cited 2024 Jul 29];(6903). Available from: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2445749
17. Clark ML, Peel JL, Balakrishnan K, Breysse PN, Chillrud SN, Naeher LP, et al. Health and household air pollution from solid fuel use: the need for improved exposure assessment. Environ Health Perspect. 2013;121(10):1120–8.
18. Vardoulakis S, Giagloglou E, Steinle S, Davis A, Sleeuwenhoek A, Galea KS, et al. Indoor exposure to selected air pollutants in the home environment: a systematic review. Int J Environ Res Public Health. 2020;17(23):8972.
19. Raju S, Siddharthan T, McCormack MC. Indoor air pollution and respiratory health. Clin Chest Med. 2020;41(4):825–43.
20. Abubakar IR, Alola AA, Bekun FV, Onifade ST. Investigating the determinants of household energy consumption in Nigeria: insights and implications. Energ Sustain Soc. 2024;14(1):29.
21. Bisu DY, Kuhe A, Iortyer HA. Urban household cooking energy choice: an example of Bauchi Metropolis, Nigeria. Energ Sustain Soc. 2016;6(1):15.
22. Pona HT, Xiaoli D, Ayantobo OO, Tetteh ND. Environmental health situation in Nigeria: current status and future needs. Heliyon [Internet]. 2021 [cited 2024 Aug 31];7(3). Available from: https://www.cell.com/heliyon/fulltext/S2405-8440(21)00435-7
23. Ahamad MG, Tanin F. Estimation of household smoke-exposure risk using demographic and health survey (DHS) data. MethodsX. 2021;8:101390.
24. Rahut DB, Ali A, Mottaleb KA, Aryal JP. Wealth, education and cooking-fuel choices among rural households in Pakistan. Energy Strategy Reviews. 2019;24:236–43.
25. Lindgren SA. Clean cooking for all? A critical review of behavior, stakeholder engagement, and adoption for the global diffusion of improved cookstoves. Energy Res Social Sci. 2020;68:101539.
26. Li F, Chandio AA, Duan Y, Zang D. How does clean energy consumption affect women's health: new insights from China. Int J Environ Res Public Health. 2022;19(13):7943.
27. Jekayinfa SO, Orisaleye JI, Pecenka R. An assessment of potential resources for biomass energy in Nigeria. Resources. 2020;9(8):92.
28. Karanja A, Gasparatos A. Adoption and impacts of clean bioenergy cookstoves in Kenya. Renew Sustain Energy Rev. 2019;102:285–306.
29. Roche MY, Slater J, Malley C, Sesan T, Eleri EO. Towards clean cooking energy for all in Nigeria: pathways and impacts. Energy Strategy Reviews. 2024;53:101366.
30. Sani J, Ahmed A, Wagini Hassan A, Wali I, Ahmad B, Danjuma M. Regional disparities and Socio-demographic determinants of clean cooking energy use among women in Nigeria. Dutse J Pure Appl Sci. 2024;10:299–308.
31. Habtamu D, Abebe B, Seid T. Health risk perceptions of household air pollution and perceived benefits of improved stoves among pregnant women in rural Ethiopia: a mixed method study. BMJ Open. 2023;13(8):e072328.
32. Ang'u C. Analysis of Clean Energy Technologies' Effects on Energy Poverty: Household Air Pollution and Human Health in Vihiga County, Kenya [Internet] [PhD Thesis]. University of Nairobi; 2023 [cited 2024 Aug 27]. Available from: http://erepository.uonbi.ac.ke/handle/11295/164250
33. Gele A. Challenges facing the health system in Somalia and implications for achieving the SDGs. Eur J Pub Health. 2020;30(Supplement5):ckaa165–1147.
34. Goal 3. Ensure healthy lives and promote well-being for all at all ages — SDG Indicators [Internet]. [cited 2024 Oct 30]. Available from: https://unstats.un.org/sdgs/report/2017/goal-03/

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