

# An assessment of health consequences of Fossil Fuel energy use in Osun State, Nigeria: Burden and Implications

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## Research Article

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# Abstract

## Background

The use of fossil fuel energy still persists in all continents of the world especially in Africa. This study was aimed to examine fossil fuel energy usage and its health implication on residents of Osun State, Nigeria.

## Methods

This was a cross sectional study done across Osun State Nigeria. The study took place between January to June 2020. 1044 participants were recruited by multi stage random sampling. Structured questionnaires were used to obtain necessary information from the study participants. Statistical analysis was done with SPSS 24.0.  $P < 0.05$  was taken as statistically significant.

## Results

There were 534 females (51.1%). Fossil fuel energy was common among study participants as 601(57.6%) relied solely on fossil fuel energy compared to 443(42.4%) who uses non-traditional energy sources. There were 534 females (51.1%). Fossil fuel energy was common among study participants as 601(57.6%) relied solely on fossil fuel energy compared to 443(42.4%) who uses modern energy sources. The proportion of people whose annual monthly income is less than one hundred and twenty US Dollars (fifty thousand Naira) is far higher among those who used fossil fuel energy (88.0%) compared to those who used modern energy (59.1%). Electricity consumption accessibility was also more likely among those who used modern energy (91.9%) compared to 52.4% of those that uses fossil fuel energy for daily energy needs.

## Conclusion

This study showed that fossil fuel energy use is very prevalent among residents of Osun State, Nigeria. and is linked with many indices of poverty. It is associated with significant health impact including respiratory diseases and poor quality of life. There is need to encourage and implement policies towards effective and efficient energy use among residents in Osun State to reduce the associated long term health impact.

## Introduction

Energy is an important prerequisite of life and useful for variety of things.<sup>1</sup> Despite the evolution of newer sources of energy including renewable energy, solar energy among others, the use of fossil fuel which is

also known as traditional energy still persists in all continents of the world especially in Africa, India and Asia. Indoor air pollution is a major environmental hazard especially in resource limited settings.<sup>2,3</sup> Energy systems including fossil fuel energy provides significant benefits for human health. It also directly or indirectly impacts on human health leading to premature death and ill-health. Air pollution from incomplete combustion of fossil fuels and biomass fuels is by far the single major reason that energy systems negatively affect global health.<sup>3</sup>

Fossil fuel energy including biomass has significant impact on health both locally and globally.<sup>2,3</sup> The increased in particulate matter and air pollution associated with biomass use as a form of fossil fuel energy is a known occupational hazard associated with various jobs in developing countries.<sup>4,5</sup> Even within major policy formulation and changes to mitigate the impact of climate change, fossil fuel energy and its impact on health will continue to be a major contributor to the global burden of disease worldwide.<sup>6-8</sup>

The consequences of indoor air pollution as a result of use of fossil fuel energy include respiratory illnesses, cardiovascular diseases, cancer, endocrine abnormalities and pregnancy-related complications.<sup>3,6,8</sup> Exposure to these factors doubles the risk for poor health outcome predominantly among women and children in rural communities as they are directly involved in household activities.<sup>9,10</sup> The Global Energy Alliance (GEA) in 2005 estimates that the burden of disease caused by household air pollution was responsible for up to 2.2 million premature deaths annually which occurs mainly among women and young children in developing countries as they are the highly exposed group from air pollution from cooking and heating with fossil fuel energy. While the fraction of households relying on solid/fossil fuels is slowly declining worldwide, absolute numbers are still rising in the world's poorest.<sup>11-13</sup>

This study was aimed at examining traditional or fossil fuel energy usage and its health implication on residents of Osun State, Nigeria and to study the association with socioeconomic status and poverty indices.

## Material And Methods

This was a cross sectional study done across the three senatorial districts of Osun State Nigeria. The study took place between January to June 2020. Osun State was created in 1991 and is one of the thirty-six functional and economic units/states of Nigeria. It has an estimated population of 3,416,959 from the 2006 population Census with a landmass of 9,251km<sup>2</sup>. It is the ninth smallest and nineteenth most populous state in Nigeria. Agriculture is the mainstay of economy in Osun State. It has thirty local governments. A report published in 2020 from the National Bureau of Statistics showed that Osun State has a poverty index of 8.52 which is third nationwide behind Lagos and Delta States. Despite the relative improvement in standard of life marked by increase in life expectancy and reduction in poverty rate in the state since return to democracy in 1999, the use of traditional/fossil fuel energy still persists.

Two local governments were selected from each senatorial district. The selected local governments were Odo –Otin and Osogbo from Osun Central senatorial district, Oriade and Ife North from Osun East senatorial district and Ejigbo and Irewole from Osun West Senatorial district.

One thousand and forty-four participants across the state were recruited by multi stage random sampling across the state. Structured questionnaires were used to obtain necessary information from the study participants. This study was conducted with households in three senatorial districts of Osun State: Osun West, Osun East and Osun Central. A multi-staged sampling technique was employed and 1200 questionnaires were distributed in the six local government areas sampled across the state. Of these, 1044 were completely filled and returned upon which statistical analysis was based upon. A random number table was used to identify the respondents of the participants after appropriate mapping and localization across each of the local government secretariat towns. Allocations were made to include very strata of social class in each local government secretariat. The data were obtained by trained research assistants who were well trained before the study. When a household is selected to participate in the survey, either the husband or the wife was allowed to fill the questionnaire or in the event that both of them were around at the time of interrogation, a probability assessment using playing card was used to determine who should be the respondent to the questionnaire. For those households who are single or only one of them is present at the time of visit, the questionnaire was filled by the single member household or the only available member of the household available at the time of visit.

The questionnaire contained information related to the demography of participant, poverty statistics, use of fossil fuel and renewable/modern energy, and other questions related to presence of health consequences of use of fossil fuel energy such as respiratory diseases like asthma, chronic obstructive pulmonary disease etc. Subjects were included if they were willing to participate and gave a written informed consent, more than 18 years old and had no major debilitating illness like psychiatric disease that could affect their judgment. Exclusion criteria include failure to give informed consent, less than 18 years of age or had psychiatric diseases.

Statistical analysis was done with the aid of Statistical Package for Social Sciences SPSS 23.0 Chicago Ill, USA). Qualitative data were expressed in frequencies and percentages. Continuous variables were expressed as means  $\pm$  Standard deviation. Comparison between qualitative variables were assessed using the chi square while student's t test was used between continuous variables. Institutional ethical approval was obtained for the study and all participants gave a written informed consent to participate. **All methods were performed in accordance with the relevant guidelines and regulations in the Declarations of Helsinki.**

## Results

The study participants included 1044 people across the state of Osun, Nigeria including rural and urban areas. There were 534 females (51.1%). Fossil fuel energy was common among study participants as 601(57.6%) relied solely on traditional/fossil fuel energy compared to 443(42.4%) who uses modern

energy sources. A larger proportion of those who used fossil fuel energy were females compared to those who use modern energy. Majority of those who use fossil fuel energy were in the age group 41–60 years followed by 25–40 years of age whereas those who used modern energy were mostly in the age range of 25–40 years of age. The level of education was significantly different between those that used fossil fuel energy compared to those who used modern energy as those that used fossil fuel energy were less likely to have a higher education compared to those that used modern energy (Only 12.4% of those who used fossil fuel energy had an NCE/OND/First degree or postgraduate degree compared to 65% of those that used modern energy as shown in Table 1. Polygamy was also more frequent among fossil fuel energy users compared to those who used modern energy (56.6% vs. 23.9%,  $p < 0.05$ ). Participants who used fossil fuel energy were more likely to have more dependants than those who used modern energy. 42.3% of those who used fossil fuel energy had at least six dependants compared to 19.9% in the other group,  $p < 0.05$ ). Similarly, they were more likely to be self-employed/underemployed than those who used modern energy sources (88.4% vs. 46.3%,  $p < 0.05$ ). Also, a significant majority of participants who used fossil fuel energy were living in rural areas (64.1%) compared to those that used modern energy sources where only 48.8% of them were living in rural areas as shown in Table 1.

The health consequence of traditional energy usage is shown in Table 2. Majority of those that used fossil fuel energy used firewood in cooking (78.5%) compared to 27.5% of those who used modern energy sources who also possibly occasionally used firewood additionally in cooking with most of them believing that firewood is detrimental to health and environment.

Majority also believed that ventilation is necessary where they are cooking especially among those that used fossil fuel energy where 82.7% had the belief that ventilation is important where they are cooking as against 63.9% of those that used modern energy. There were 534 females (51.1%). Traditional/fossil fuel energy was common among study participants as 601(57.6%) relied solely on fossil fuel energy compared to 443(42.4%) who used modern energy sources as shown in Table 2. Reports of other members of the family with a wheeze were however more significantly higher among those who used modern energy compared to those who used fossil fuel energy.

The poverty indices among study participants are shown in Table 3. 51.6% of those that used fossil fuel energy were living in rented apartments from various quarters compared to 53.2% of those who used modern/ renewable energy who were most likely living in urban areas and were less likely to be living in their personal houses. Dependence on support either from family credit, other member of the household who received support, jobseekers' allowance, housing benefit or retirement benefit were more likely among those that used traditional energy compared to those that used modern energy as shown in Table 3. The average monthly income was also significantly higher among those used modern energy than those that used fossil fuel energy. The proportion of people whose annual monthly income is less than 120 USD (fifty thousand Naira) is far higher among those who used fossil fuel energy (88.0%) compared to those who used modern energy (59.1%). Electricity consumption accessibility was also more likely among those who used modern energy (91.9%) compared to 52.4% of those that used fossil fuel energy for daily energy need as shown in Table 3.

Table 1  
showing the baseline characteristics of study participants in this study

Variables		Fossil Fuel Energy 601(57.6%)	Modern Energy 443(42.4%)	P value
Females (n)		327(60.6%)	213(39.4%)	0.043
Age range (yrs)	> 60	98(16.3%)	21(4.7%)	0.000
	41–60	252(41.9%)	142(32.1%)	
	25–40	196(32.6%)	217(49.0%)	
	18–24	55(9.2%)	63(14.2%)	
Level of education	No formal education	235(39.1%)	46(10.4%)	0.000
	School Cert	217(36.1%)	68(15.3%)	
	Tech/ Grd II	75(12.5%)	41(9.3%)	
	NCE	15(2.5%)	44(9.9%)	
	OND	40(6.7%)	79(17.8%)	
	First Degree	16(2.7%)	128(28.9%)	
	Postgraduate	3(0.5%)	37(8.4%)	
Type of marriage	Polygamous	340(56.6%)	106(23.9%)	0.000
	Monogamous	214(35.6%)	246 (55.5%)	
No of dependants	1–2	85 (14.1%)	82(18.5%)	0.000
	3–5	239(39.8%)	229(51.7%)	
	6–10	215(35.8%)	69(15.6%)	
	> 10	39(6.5%)	19(4.3%)	
Occupation	Self employed	531(88.4%)	205(46.3%)	0.000
	Paid employee	50(8.3%)	213(48.1%)	
Rural-urban status	Rural	385(64.1%)	216(48.8%)	0.016
	Urban	254(42.3%)	189(42.7%)	
*-statistically significant				

Table 2  
showed the health consequences of traditional energy in study participants

Questions	Fossil Fuel energy used (601)	Modern energy used (443)	P value
Cook with firewood	472(78.5%)	121(27.3%)	0.000*
Fire is detrimental to health	508 (84.5%)	355(80.1%)	0.039*
Firewood can affect our environment	506(84.2%)	366 (82.6%)	0.276
Ventilation where you cook	497 (82.7%)	283 (63.9%)	0.000*
Have you been sick in the last 2–6 months	126 (21.0%	61(13.8%)	0.002*
History of asthma	16(2.7%)	13(2.9%)	0.954
Asthma illness	92(15.3%)	50(11.3%)	0.037*
Catarrh	127(21.1%)	74(16.7%)	0.032*
Any other member of you house had running nose in the last 1 month?	99(16.5%)	78(17.6%)	0.344
Had cough in the last 1 month?	116(19.3%)	48(10.8%)	0.000*
Frequently producing phlegm in the last 1 month	97(16.1%)	46(10.4%)	0.005*
Wheeze in the last 1 month?	42(7.0%)	31(7.0%)	0.544
Shortness of breath in the last 1 month	56(9.3%)	29(6.5%)	0.065
Any other member of the family with shortness of breath?	46(7.7%)	27(6.1%)	0.197
Any other member of the family with chest tightness /pain in the last 1 month	59(9.8%)	31(7.0%)	0.067
Difficulty in breathing in the last 1 month?	56(9.3%)	28(6.3%)	0.049*
*-statistically significant			

Table 3

showing the poverty indices among participants who use traditional energy and those who uses other forms of energy

Variables		Fossil Fuel energy (601)	Modern energy (443)	P value
Type of house occupation	Owned outright	276(45.9%)	192(43.3%)	0.000*
	mortgage	3(5.0%)	7(1.6%)	
	Rent from local authority	132(22.0%)	44(9.9%)	
	Rent from housing authority	62(10.3%)	71(16.0%)	
	Rent from landlord	116(19.3%)	121(27.3%)	
	Others	12(2.0%)	8(1.8%)	
No of people in the house that receive family credit	None	552(91.8%)	360(81.3%)	0.000*
	1	21(3.5%)	28(6.3%)	
	2	14(2.3%)	19(4.3%)	
	3	4(0.7%)	12(2.7%)	
	No answer	10(1.7%)	24(5.4%)	
No of people in household that receive income support	NIL	563(93.7%)	366(82.6%)	0.000*
	1	15(2.5%)	29(6.5%)	
	2	15(2.5%)	20(4.5%)	
	3	2(0.3%)	8(1.8%)	
	No answer	6(0.99%)	20(4.5%)	
No of people who receive jobseekers' allowance	Nil	575(95.7%)	397(89.6%)	0.001*
	1	14(2.3%)	14(3.2%)	
	2	5(0.83%)	9(2.0%)	
	3	0(0.0%)	3(0.7%)	
	No answer	7(1.16%)	20(4.5%)	
No of people in household that receive housing benefit	Nil	574(95.5%)	394(88.9%)	0.000*
	1	18(3.0%)	22(5.0%)	
*-statistically significant				

Variables		Fossil Fuel energy (601)	Modern energy (443)	P value
	2	6(1.0%)	8(1.8%)	
	3	0(0%)	3(0.7%)	
	No answer	3(0.5%)	16(3.6%)	
No of people in household who receive retirement benefit	Nil	571(95.0%)	392(88.5%)	0.000*
	1	17(2.8%)	20(4.5%)	
	2	7(1.2%)	8(1.8%)	
	3	0(0%)	3(0.7%)	
	No answer	6(1.0%)	20(4.5%)	
No of people in household who receive occupational benefit	Nil	578(96.2%)	405(91.4%)	0.001*
	1	9(1.5%)	13(2.9%)	
	2	9(1.5%)	5(1.1%)	
	3	1(0.2%)	5(1.1%)	
	No answer	4(0.7%)	15(3.4%)	
Average monthly income	< 50,000	529(88.0%)	262(59.1%)	0.000*
	51,000-100,000	50(8.3%)	110(24.8%)	
	100,000-150,000	10(1.7%)	46(10.4%)	
	> 150,000	5(0.83%)	18(4.1%)	
Electricity consumption (Yes)		315(52.4%)	407(91.9%)	0.000*
*-statistically significant				

## Discussion

Energy is fundamental to socioeconomic development and poverty eradication. The situation in the rural areas of the country is that most end users depend on fuel wood. Fuel wood is used by over 70% of Nigerians living in the rural areas.<sup>14,15</sup> This is similar to what was found in this study where at least 70% used at least one of fossil fuel energy for cooking. This is despite the fact that Nigeria is the sixth largest reservoir of crude oil in the world and the sixth largest producer of oil.<sup>14</sup> Each source of energy is associated with certain health risk risk.<sup>3,8</sup> The use of solid fuels, coal and biomass majorly from occupational hazard and indoor exposure and general ambient air pollution is responsible for the biggest health impact.<sup>8,10</sup> Poor access to fuel and electricity in poor households is particularly a serious risk for health. In 2005, the Global Energy Assessment estimates that approximately 2.8 billion people mostly in

the world poorest regions relied on solid fuels such as biomass, charcoal and coal for cooking and other household needs.<sup>16</sup> This was reflected in the demography of this study participants using fossil fuel energy who were majorly females, majority of whom had little or no education, likely to be polygamous, with large family size, lack of retirement support, older than forty years and were likely to be living in rural areas. Majority of these factors are directly or indirectly related to low socioeconomic status and the findings are similar to other studies from other population.<sup>17,18</sup>

According to the World Health Organization (WHO), each year, close to 4 million people die prematurely from illnesses attributable to household air pollution from inefficient cooking practices. Household air pollution has been related to non-communicable diseases including stroke, restrictive lung disease, ischaemic heart disease, chronic obstructive pulmonary disease (COPD) and lung cancer.<sup>19,20</sup> The inefficient cooking methods leads to high levels of household air pollution with a range of health damaging pollutants including small particles that penetrate deep into the lungs. Indoor air pollution can be more than a 100 times acceptable limits for fine particles.<sup>21,22</sup> Exposure is especially high among women and children who spend the greater part near domestic activities. This is also reflected in this study as more females were exposed to fossil fuel energy than modern energy use.

In household air pollution, chemical such as carbon monoxide and particle sizes are commonly measured. However, there are other products of incomplete combustion found in solid fuel smoke such as oxides of nitrogen, phenols, quinones/semiquinones, chlorinated acids such as methylene chloride and dioxins, some of which are carcinogenic.<sup>23</sup> The high particulate matter exposure over the years result in mean concentrations and exposures in excess of acceptable levels and exposure is influenced by multiple household level, individual determinant such as fuel type, kitchen location, use and maintenance of stoves, household layout and ventilation, time activity profiles of household members and behavioral practices.<sup>24,25</sup> Household air pollution is a major risk for poor health. According to the Global burden of disease, most chronic respiratory diseases associated deaths and diseases adjusted life years (DALYs) were attributable to COPD with mortality rates greatest in south Asia and lowest in sub-Saharan Africa.<sup>26</sup>

The significant health implications documented in this study is most likely reflective of the impact of fossil fuel energy use over a fairly long duration and it is a wake-up call for initiation of transition to efficient, cleaner, effective energy in Osun State, Nigeria for improved health status and reduced health associated pollution in our environment. A very large proportion of participants (almost four-fifth) used firewood as against about one-fourth of those that used modern energy. Majority of them believed that it had impact on their health and environment with that on their health been significantly pronounced among those who used fossil fuel energy. A larger proportion of those who used fossil fuel energy have also reported been sick in the last two-to six months compared to those who used modern energy. This is reflective of poor quality of life, absenteeism poor work output and reduced productivity. The proportion of related complaints such as cough, catarrh, sputum/phlegm production were significantly more common among those who used fossil fuel energy than those that do not. Similarly, history of symptoms

suggestive of asthma/diagnosis of asthma were more likely significantly commoner among those who used fossil fuel energy compared to those who do not. Similarly, the likelihood of having difficulty in breathing in the last one month was more significantly commoner among fossil fuel energy users compared to modern energy users. This suggests a very high health burden and reduced quality of life among those that used fossil fuel energy compared to those who used modern/renewable energy. The symptoms of chronic obstructive pulmonary diseases are described by the population often as asthma-like in our environment. This therefore, may reflect the burden of COPD among study participants which may be directly or indirectly linked to household air pollution and outdoor air pollution from smoke and traffic waste. COPD is the fourth leading cause of death globally is characterized by airway limitation associated with chronic airway and lung inflammation in response to exposure to particles and gases.  
27,28

This study further corroborates the fact that household air pollution with its attendant long-term impact and implications may contribute to the silent epidemic of COPD in Africa. The crude prevalence of COPD in Africa is reported to be as high as 4.1–24.8% of adult population.<sup>29</sup> The authors also suggested that the impact of household air pollution might be more important than smoking in the aetiology of COPD in Africa.<sup>29</sup> Whether directly or indirectly, COPD has been associated with poverty. They therefore have limited access to quality health care among other services which may herald a debilitating progression of the illness associated with poor prognosis and increasing death rate.<sup>30–32</sup>

This is apparent in this study as a larger proportion of people who used fossil fuel energy were receiving one form of support or the other either income support from children and families, retirement benefit or jobseekers support or family credit compared to those who were using modern energy. The use/access to electricity was also significantly lower among those who used fossil fuel energy, a good reflection of low socioeconomic status in the participants. The association of COPD with poverty as even been verified in economically advantaged countries such as Denmark where low socioeconomic status was associated with poorer clinical prognosis of COPD.<sup>33</sup>

This study has some limitations: First, it did not capture the whole spectrum of disorders such as cardiovascular diseases, lung cancers among others. which are also possibilities from household air pollution. Also, the findings of this study may not be completely explained by the variables because of the cross-sectional study design. A long-term prospective follow up would have been more appropriate. Nonetheless, a major strength of this study is the relatively large size of the participants and the sampling pattern to involve six local governments in Osun State representing the entire state.

## Conclusion

This study showed that fossil fuel energy use is very prevalent among residents of Osun State, Nigeria and is linked with many indices of poverty such as low use of electricity, low average monthly income, likelihood of having a large family size, with high dependency ratio, being polygamous and dependence on support system such as family credit, retirement benefit. It also showed significant health impact

including respiratory diseases and poor quality of life associated with traditional energy among participants in this study. There is need to encourage and implement policies towards effective and efficient energy use especially clean energy among residents in Osun State to reduce the associated long term health impact on them.

## List Of Abbreviations

GEA-Global Energy Alliance

OND-Ordinary national Diploma

HND- Higher National Diploma

COPD-Chronic Obstructive Pulmonary Disease

DALY-Disease Adjusted life years

WHO-World Health Organization

## Declarations

**Ethics approval and consent to participate:** Institutional Ethical approval was obtained from the Research Ethics Board of LAUTECH Teaching Hospital, Ogbomoso, Nigeria. The study conforms to the International Guideline on Declaration of Helsinki. A written informed consent was obtained from all participants.

**Consent for publication:** Not Applicable

**Availability of data and materials:** The datasets generated and/or analysed during the current study are not publicly available due to the funding agency term of reference but are available from the corresponding author on reasonable request.

**Competing interests:** Nil

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**Authors' contributions:** ATS: Conceptualization; Data curation; Funding acquisition; Investigation; Methodology; Project administration; Resources; Software; Supervision; Validation; Visualization; Roles/Writing; Writing - review & editing.

AAA: Formal analysis; Validation; Visualization; Roles/Writing - original draft; Writing - review & editing.

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## References

1. Kim K-H, Jahan SA, Kabir E. A review of diseases associated with household air pollution due to the use of biomass fuels. *J Hazard Mater.* 2011;192(2):425–31.
2. Faizan, M.A., Thakur, R. Measuring the impact of household energy consumption on respiratory diseases in India. *Glob Health Res Policy.*2019; 4, 10. <https://doi.org/10.1186/s41256-019-0101-7>.
3. Fullerton DG, Bruce N, Gordon SB. Indoor air pollution from biomass fuel smoke is a major health concern in the developing world. *Trans R Soc Trop Med Hyg.* 2008;102(9):843–51.
4. Akintunde AA, Adeniran J, Akintunde TS, Oloyede TO, Salawu AA, Opadijo OG. Air quality index and cardiovascular risk factors among automobile technicians in Southwest Nigeria. *Nig J. Cardiol* 2019; 16:32–7.
5. Oloyede T, Akintunde AA, Adeniran JA, Tanimowo MO, Fawibe EA, Salami AK. Lung function abnormalities among garri processing workers in Ogbomoso, Nigeria. *Niger Postgrad Med J.* 2018;25(3):149–155.
6. Samet JM, Dearry A, Eggleston PA et al. Urban air pollution and health inequities: A workshop report. *Environ Health Perspect.* 2001; 109 (Suppl. 3): 357–74
7. Perera F. Pollution from Fossil-Fuel Combustion is the Leading Environmental Threat to Global Pediatric Health and Equity: Solutions Exist. *Int J Environ Res Public Health.* 2017;15(1):16.
8. Watts N, Adger WN, Agnolucci P, Blackstock J, Byass P, Cai W, et al. Health and climate change: Policy responses to protect public health. *Lancet.* 2015; 386:1861–1914.
9. Smith KR, Mehta S. The burden of disease from indoor air pollution in developing countries: comparison of estimates. *Int J Hyg Environ Health.* 2003;206(4–5):279–89.
10. Fullerton DG, Bruce N, Gordon SB. Indoor air pollution from biomass fuel smoke is a major health concern in the developing world. *Trans R Soc Trop Med Hyg.* 2008;102(9):843–51.
11. Viegi G, Simoni M, Scognamiglio A, Baldacci S, Pistelli F, Carrozzi L, Annesi-Maesano I. Indoor air pollution and airway disease. *Int J Tuberc Lung Dis.* 2004;8(12):1401–15.
12. Torres-Duque C, Maldonado D, Pérez-Padilla R, Ezzati M, Viegi G; Forum of International Respiratory Studies (FIRS) Task Force on Health Effects of Biomass Exposure. Biomass fuels and respiratory diseases: a review of the evidence. *Proc Am Thorac Soc.* 2008;5(5):577–90.
13. Bonjour S, Adair-Rohani H, Wolf J, et al. Solid fuel use for household cooking: country and regional estimates for 1980–2010. *Environ Health Perspect.* 2013;121(7):784–790.
14. Oyedepo: Energy and sustainable development in Nigeria: the way forward. *Energy, Sustainability and Society* 2012; 2:15.
15. Sambo AS. Matching Electricity Supply with Demand in Nigeria. *International Association of Energy Economics* 2012; 4:32–36.
16. Gohlke JM, Thomas R, Woodward A, Campbell-Lendrum D, Pruss Ustun A, et al. Estimating the global public health implications of electricity and coal consumption. *Environ. Health Perspect.*2011; 119:821–826.

17. Prescott E, Vestbo J. Socioeconomic status, lung function and admission to hospital for COPD: results from the Copenhagen City Heart Study. *Eur Respir J.* 1999; 13:1109–1114.
18. Van Gemert F, Chavannes N, Kirenga B, et al. Socioeconomic factors, gender and smoking as determinants of COPD in a low income country of sus-Saharan Africa: FRESH AIR Uganda. *npj Prim Care Resp Med.*2016;26: 16050.
19. WHO. Household air pollution and health. Key facts. Available on [www.who.int/news-room/fact-sheets/detail/hosuehold-air-pollution-and-health](http://www.who.int/news-room/fact-sheets/detail/hosuehold-air-pollution-and-health). Accessed on 1st April 2022.
20. Hosgood H III, Wei H, Sapkota A, Choudhury I, Bruce N, et al. Household coal use and lung cancer: systematic review and meta-analysis of case-control studies, with an emphasis on geographic variation. *Int. J. Epidemiol.* 2011; 40:719–28.
21. Lim SS, Vos T, Flaxman AD, Danaei G, Shibuya K, et al. A comparative risk assessment of burden of disease and injury attributable to 67 risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet.* 2012; 380:2224–2260.
22. Pope CA 3rd, Burnett RT, Turner MC, Cohen A, Krewski D, et al. 2011. Lung cancer and cardiovascular disease mortality associated with ambient air pollution and cigarette smoke: shape of the exposure. response relationships. *Environ. Health Perspect.*2011; 119:1616–1621.
23. Tolunay E, Chockalingam A, eds. *Indoor and Outdoor Air Pollution, and Cardiovascular Health. Global Heart* (Spec. Issue) 2012;7(3):197–274.
24. Bell ML, Davis DL, Cifuentes LA, Krupnick AJ, Morgenstern RD, Thurston GD. Ancillary human health benefits of improved air quality resulting from climate change mitigation. *Environ. Health* 2008;7:41
25. Babatola SS. Global burden of diseases attributable to air pollution. *J Public Health Afr.* 2018;9(3):772.
26. GBD Chronic respiratory Disease Collaborators. Prevalence and attributable health burden of chronic respiratory diseases, 1990–2017: a systematic analysis for the Global burden of Disease study 2017. *Lancet Respirat Med.* 2020;8(6):585–596.
27. GBD risk factors collaborators. 2015. Global, regional and National comparative Risk Assessment of 79 behavioral, environmental, occupational and metabolic risks or clusters of risks in 188 countries, 1999–2013: A systematic analysis for the Global Burden of Disease study 2013. *The Lancet* 2015;386(10010):2287–2323.
28. GOLD (Global Initiative for chronic Obstructive Lung Disease). 2016. Global strategy for the diagnosis, management and prevention of COPD. GOLD. <http://www.goldcopd.org/>.
29. Salvi S. The silent epidemic of COPD in Africa. *The Lancet Global Health.* 2015;3(1):e6-e7.
30. Cho KH, Nam CM, Lee EJ, et al. Effects of individual and neighborhood socioeconomic status on the risk of all-cause mortality in chronic obstructive pulmonary disease: A nationwide population-based cohort study, 2002–2013. *Respir Med* 2016; 114:9–17.
31. Burney P, Jithoo A, Kato B, et al. Chronic Obstructive Pulmonary disease mortality and prevalence: the associations with smoking and poverty-a BOLD analysis. *Thorax* 2014; 69:465–473.

32. Lange P, Marott JL, Vestbo J et al. Socioeconomic status and its relationship to chronic respiratory disease. *Adv Respir Med*. 2017;85:97–108.
33. Clark AJ, Strandberg-Larsen K, Masters Pedersen JL, Lange P, Prescott E, Rod NH. Psychosocial risk factors for hospitalization and death from chronic obstructive pulmonary disease: a prospective cohort study. *COPD*. 2015 Apr;12(2):190–8. doi: 10.3109/15412555.2014.922175. Epub 2014 Jun 24. PMID: 24960441.