

## Assessment of health consequences of fossil fuel energy use in Osun state, Nigeria: burden and implications

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Received: 15 September 2023 / Accepted: 15 April 2024

Published online: 18 April 2024

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### Abstract

The use of fossil fuel energy persists in all the continents of the world, especially in Africa. This study examined fossil fuel energy usage and its health implications in residents of Osun State, Nigeria. This was a cross-sectional study done across Osun State Nigeria. The study took place between January and June 2020. 1044 participants were recruited by multi-stage random sampling. Structured questionnaires were used to obtain necessary information from the study participants. The study data shows there were 534 females (51.1%). 601 (57.6%) relied solely on fossil fuel energy compared to 443 (42.4%) who use non-traditional energy sources. The proportion of people whose annual income is less than 56.6 USD (fifty thousand Naira based on the current official exchange rate as of Jan 2024) is far higher among those who use fossil fuel energy (88.0%) compared to those who use 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 who use fossil fuel energy for daily energy needs. Reports of ill-health were significantly commoner among those who used fossil fuel than modern energy in the population including asthma illness (15.3% vs. 11.3%), cough (21.1% vs. 16.7%), catarrh (19.3% vs. 10.8%) and difficulty in breathing (9.3% vs. 6.3%) respectively. This study showed that fossil fuel energy use is very prevalent among residents of Osun State, Nigeria. And may be linked with many indices of poverty. It is associated with significant health impacts including respiratory diseases and poor quality of life. There is a need to encourage and implement policies toward effective and efficient energy use among residents in Osun State to reduce the associated long-term health impact.

**Keywords** Fossil fuel (traditional) energy · Health implications · Osun State · Nigeria · Health impact assessment · Public health

### Abbreviations

OND	Ordinary national diploma
HND	Higher national diploma
COPD	Chronic obstructive pulmonary disease
DALY	Disease adjusted life years
WHO	World Health Organization

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## 1 Introduction

Energy is an important prerequisite of life and useful for a variety of things [1]. Despite the evolution of newer sources of energy including renewable energy among others, the use of fossil fuel also known as traditional energy persists in all continents of the world, especially in Africa and Asia. Indoor air pollution is a major environmental hazard and a consequence of fossil fuel energy sources, especially in resource-limited settings [2, 3]. Energy resources including fossil fuel energy provide significant benefits for human health. It also directly or indirectly impacts human health leading to premature death and ill health [1–3]. Air pollution from the complete and incomplete combustion of fossil fuels and biomass fuels is by far the single major reason that energy resources negatively affect global health [3, 4]. The identified key drivers of these emissions include but are not limited to domestic cooking, bush burning, and agricultural activities such as land cultivation and animal rearing [5].

Fossil fuel energy resource including biomass has a significant impact on health both locally and globally [2, 3, 6]. The increase 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 [4, 7–9]. 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 [10–12] due to a lack of compliance to shifting to the use of environmentally friendly energy sources.

The consequences of indoor air pollution as a result of the use of fossil fuel energy include respiratory illnesses, cardiovascular diseases, cancer, endocrine abnormalities, and pregnancy-related complications [3, 6, 9, 10, 12]. Exposure to these factors doubles the risk for poor health outcomes predominantly among women and children in rural communities as they are directly involved in household activities [3, 13]. The World Health Organization (WHO) estimates that over 3.8 million people die annually from premature illnesses attributable to household air pollution caused by the inefficient use of solid fuels and kerosene for cooking [12]. These illnesses include pneumonia, stroke, ischemic heart disease, chronic obstructive pulmonary disease, and lung cancer. While the fraction of households relying on solid/fossil fuels is slowly declining worldwide, absolute numbers are still rising in the world's poorest region [14–16]. Africa continues to face a serious economic challenge. With a comparatively lower lifespan compared to Caucasians, the call for energy transition has not been widely implemented in many countries. Information on the use of fossil fuel in many African states is scarce coupled with the direct and indirect impact of traditional (fossil) energy usage. This study was aimed at examining traditional or fossil fuel energy usage and its self-reported health implications on residents of Osun State, Nigeria.

### 1.1 Material, setting, and methods

This was a cross-sectional study. The study took place between January and June 2020 across the three senatorial districts of Osun State Nigeria. 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 9251 km<sup>2</sup>. It is the ninth smallest and nineteenth most populous state in Nigeria. Agriculture is the mainstay of the 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 the standard of life marked by an increase in life expectancy and a reduction in the poverty rate in the state since the return to democracy in 1999, the use of traditional/fossil fuel energy persists. Two local governments were randomly 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.

### 1.2 Participants

One thousand and forty-four participants across the state filled out their questionnaire and were recruited by multi-stage random sampling across the state. Structured researcher-made and validated questionnaires were used to obtain necessary information from the study participants. Validation of the questionnaire was done by a pilot study among a similar population. 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 filled and returned upon which statistical analysis was based. 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 every stratum 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 out the questionnaire or if both of them were around at the time of interrogation, a probability assessment using a 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 the visit, the questionnaire was filled by the single-member household or the only available member of the household available at the time of the visit.

The questionnaire contained information related to the demography of participants, poverty statistics, use of fossil fuel and renewable/modern energy, and other questions related to the presence of health consequences of the 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 written informed consent, were 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, being less than 18 years of age, or the presence of psychiatric disease.

### 1.3 Statistical analysis

Statistical analysis was done with the aid of Statistical Package for Social Sciences SPSS 24.0 Chicago III, USA). Qualitative data were expressed in frequencies and percentages. Continuous variables were expressed as means  $\pm$  standard deviation. Comparison between qualitative variables was 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 written informed consent to participate. All methods were performed following the relevant guidelines and regulations in the Declarations of Helsinki.

## 2 Results

### 2.1 Socioeconomic characteristics of study participants

The study participants included 1044 people across Osun state, 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 used modern energy sources. A larger proportion of those who used fossil fuel energy were females compared to those who used modern energy. The majority of those who used 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 who 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% of those who used modern energy,  $p < 0.05$ ). 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 who used modern energy sources where only 48.8% of them were living in rural areas as shown in Table 1.

### 2.2 Health consequences of fossil fuel usage among study participants

The health consequences of traditional energy usage are shown in Table 2. The majority of those who 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.

**Table 1** Socio-demographic characteristics of study participants

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

Key to table: Tech-technical schools, NCE- National certificate in Education, OND-Ordinary National Diploma, HND- Higher National Diploma, Grd II- Grade II Certificate

**Table 2** Differences of health consequences between traditional vs. modern energy users in Osun State, Nigeria

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

The 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. Reports of other members of the family with a wheeze were however significantly higher among those who used modern energy compared to those who used fossil fuel energy. Reports of ill health were significantly commoner among those who used fossil fuel than modern energy in the population including asthma illness (15.3% vs. 11.3%), cough (21.1% vs. 16.7%), catarrh (19.3% vs. 10.8%) and difficulty in breathing (9.3% vs. 6.3%) respectively. Those who used fossil fuel energy were more likely to produce phlegm in the last month compared to those who used modern energy sources as shown in Table 2 (16.1% vs. 10.4%,  $p < 0.05$  respectively). A greater proportion of those who used fossil fuel energy were more likely to report illness in the last two months compared to those who used modern energy (21.0 vs. 13.8% respectively,  $p < 0.05$ ). Reports of wheezing or similar episodes in a family member were not significantly different between the two groups as shown in Table 2.

### 2.3 Socioeconomic differences between participants who use traditional and modern energy among study participants

The poverty indices among study participants are shown in Table 3. More than half (51.6%) of those who 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 members of the household who received support, jobseekers' allowance, housing benefit, or retirement benefit were more likely among those who used traditional energy compared to those who used modern energy as shown in Table 3. The average monthly income was also significantly higher among those who used modern energy than those who used fossil fuel energy. The proportion of people whose annual monthly income is less than 56.6 USD (fifty thousand Naira based on the official Naira-Dollar exchange rate as of Jan. 2024) is far higher among those who use fossil fuel energy (88.0%) compared to those who use 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 who used fossil fuel energy for daily energy needs as shown in Table 3.

## 3 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. This study revealed that at least 70% of study participants used at least one form of fossil fuel energy for cooking in Osun State, Nigeria. This is similar to what was reported by Oyedepo et al. where he documented that fuel wood is used by over 70% of Nigerians living in rural areas [17, 18]. Every source of energy is associated with certain health risks but that of traditional energy far outweighs that of modern energy sources [3]. The use of solid fuels, coal, and biomass majorly from occupational hazards and indoor exposure, and general ambient air pollution is responsible for the biggest health impact [3, 4, 6, 12]. The correlation of fossil fuel energy use with low socioeconomic status has been shown in other reports and it was reflected in the demography of the study participants using fossil fuel energy who were majorly females, the 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. The majority of these factors are directly or indirectly related to low socioeconomic status and the findings are similar to other studies from other populations [20, 21].

### 3.1 Fossil fuel energy and health implications

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 [22, 23]. The inefficient cooking methods of using fossil fuels or traditional energy led 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 100 times the acceptable limit for fine particles in the environment [1, 23]. 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.

**Table 3** Differences of poverty indices between traditional vs modern energy users in Osun State, Nigeria

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)	
	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

In household air pollution, chemicals 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, and chlorinated acids such as methylene chloride and dioxins, some of which are carcinogenic [4, 24, 25]. The high particulate matter exposure over the years among those exposed to fossil fuel resulted in mean concentrations and exposures above acceptable levels. Exposure is further influenced by multiple household levels, individual determinants such as fuel type, kitchen location, use and maintenance of stoves, household layout, and ventilation, time activity profiles of household members, and behavioral practices [26, 27]. Household air pollution is a major risk for poor health. According to the Global Burden of Disease, most chronic respiratory disease-associated deaths

and disease-adjusted life years (DALYs) were attributable to chronic obstructive pulmonary disease with mortality rates greatest in South Asia and lowest in sub-Saharan Africa [28].

The significant health implications documented in this study are most likely reflective of the impact of fossil fuel energy use over a fairly long duration and it is a wake-up call for the 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-fifths) used firewood as against about one-fourth of those that used modern energy. The majority of them believed that it had an impact on their health and environment with that on their health being significantly pronounced among those who used fossil fuel energy [9]. A larger proportion of those who used fossil fuel energy have also reported being 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, and sputum/phlegm production were significantly more common among those who used fossil fuel energy than those who used modern energy. Similarly, a history of symptoms suggestive of asthma/diagnosis of asthma was significantly commoner among those who used fossil fuel energy compared to those who did not. Similarly, the likelihood of having difficulty breathing in the last month was more significantly common among fossil fuel energy users compared to modern energy users. This suggests a very high health burden and reduced quality of life among those who use fossil fuel energy compared to those who use 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 and is characterized by airway limitation associated with chronic airway and lung inflammation in response to exposure to particles and gases [28–30].

### 3.2 Long-term impact of fossil fuel energy use among the study participants

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 the adult population [31]. The authors suggested that the impact of household air pollution might be more important than smoking in the aetiology of COPD in Africa [31]. 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 [32].

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 benefits 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 has even been verified in economically advantaged countries such as Denmark where low socioeconomic status was associated with poorer clinical prognosis of COPD [33, 34].

### 3.3 Study limitations

This study has some limitations: First, it did not capture the whole spectrum of disorders such as cardiovascular diseases, and 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 participants and the sampling pattern to involve six local governments in Osun State representing the entire state.

## 4 Conclusion

This study concludes that fossil fuel energy resource use is very prevalent among residents of Osun State, Nigeria. It 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 systems such as family credit, and retirement benefits. It also revealed that fossil fuel energy use showed significant health impacts including respiratory diseases and poor quality of life among participants in this study. There is therefore a 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.

**Author 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.

**Funding** Tertiary Education Fund, (TETFund) Nigeria for funding this study. The grant No. is UNIOSUN/TETFund/16b/0015.

**Data availability** The datasets generated and/or analyzed during the current study are not publicly available due to the funding agency term of reference but are available from the corresponding author upon reasonable request.

## 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 the Declaration of Helsinki. A written informed consent was obtained from all participants. All authors have read, understood, and have complied as applicable with the statement on Ethical responsibilities of Authors as found in the Instructions for Authors.

**Competing interests** Nil.

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