EFFECTS OF FUELWOOD USE ON HEALTH: THE CASE OF HOUSEHOLD INFANTS IN NIGERIA

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Yakaka Bukar Maina[1]*, Bamidele Andrew Egbedimame[2] and Baba Gana Kyari[3]
[1]Department of Economics, University of Maiduguri, PMB 1069, Borno State, Nigeria
[2]Medical Centre, University of Maiduguri, PMB 1069, Borno State, Nigeria
Department of Agricultural Economics, University of Maiduguri, PMB 1069, Borno State, Nigeria
*Corresponding author: yakakabkm@unimaid.edu.ng

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Abstract: The study examines the effects of fuelwood use on health: The Case of Household Infants in Nigeria. Secondary data set from the National Demographic Health Survey (2018) was used, also descriptive statistics, Tobit and Logistic regressions were employed in this study for results analyses. A sample size of 16,685 households with infants, were used for this study out of which 9,695 households cooked in an indoor kitchen location and 6,990 cooked outdoor. The results reveal that 97% of the households has an average of 2 infants, also 90% are headed by the male who has a mean age of 43 years. The economic status indicates that most households are poor with the mean wealth index of ₦-33, 811. The respiratory symptoms recorded were cough with 34%, shortness of breath 33% and blocked nose and chest 32%. The Tobit regression analysis was used to determine the effect of fuelwood on the health of the infants and the results showed that cough was negative and also insignificant while shortness of breath, blocked chest and nose are positive and also significant at 1%, respectively. The logit regression analysis shows that cooking indoor affects the infants, and it also significantly causes both shortness of breath, blocked chest and nose, but this location of cooking is insignificantly related to cough. The study concludes that the majority of the households are poor, have infants, mostly use fuelwood in an indoor kitchen. The significant respiratory symptoms that affect the infants are shortness of breath and blocked nose and chest. Thus, government should look at creating public and media awareness on the health effects of cooking with fuelwood without the installation of smoke extractors in the households and create policies that would make the accessibility to affordable clean cooking energy among households with infants.

Keywords: Cooking, fuelwood, health, household, indoor, infants

Introduction

About half of the world's population relies on biomass fuel (wood, charcoal, crop residues, or dung) as a primary source of energy for cooking (FAO, 2019). Thus the high dependence on such exposes the household members especially the women who are responsible for cooking and the infants, usually less than five years of age to air pollution (Rinne *et al*., 2007). Moreover, the use of biomass is increasingly becoming predominant in developing countries like Nigeria, where alternative energy is becoming increasingly unaffordable due to an increase in poverty (World Bank, 2018). Likewise, wood smoke consists of various gases and respiratory chemical particles that are harmful to human health (Lidia & Junfeng, 2002). The most harmful of all the chemical particles to infants are carbon monoxide (CO) and the particulate matter (PM). CO has a significant health effect by impairing oxygen delivery to vital tissues which cause low birth weight (Levy, 2015). While particulate matter penetrates deeply into the lungs, thereby compromising the host's defense mechanisms and posing more risk for respiratory infections (Brunekreef & Holgate, 2002).

In Nigeria, more than 70% of households depend on solid fuels for cooking (Tilasto, 2018) which exposes infants living in such homes to harmful emissions of biomass smoke (Dionisio *et al*., 2008). The use of such fuel is usually done in poorly ventilated kitchens and in traditional cook stoves that have a very high concentration of pollutants (Edwards & Langpap, 2012). The resulting exposure to indoor air pollution (IAP) is higher than outdoor exposure. In the same vein, the resulting high concentration of indoor pollutant is above the level recommended (WHO, 2004). The mean concentration of pollutant recommended for Particulate $Matter_{10}$ and Particulate $Matter_{2.5}$ are 50 and 25 $\mu g/m^3$, respectively in 24 h. At the same time, typical daily concentrations in a household that uses biomass should not exceed 500 to 1,000 $\mu g/m^3$, with peak concentrations above 30,000 $\mu g/m^3$ near the fire (UNDP-WHO, 2009). Thus, the type of cooking fuel used in the household where the under-five infants are raised plays a significant role in determining their health status (Samuel *et al*., 2016).

Some of the studies that examined the relationship between the effect of cooking with fuelwood and its health implication on infants include (Rinne *et al*., 2007; Dionisio *et al*., 2008; National Family Health Survey (NFS), 1997; Edwards & Langpap, 2012). However, these studies were conducted in other countries with different socio-economic statuses, different cultural norms, kitchen locations and energy consumption habit. Also, they did not assess the extent to which indoor and outdoor air pollution differs. This study bridges a gap in research by employing econometric methods to establish an empirical link between fuelwood use, location of kitchen and health effects of infants. Hence, the study examines the socio-economic characteristics of the households that use fuelwood for cooking, the pattern of fuel used and some respiratory ailments experienced by Infants. It also determines the relationship between fuelwood use and the adverse health outcomes among infants. Finally, it assesses the variation in the extent of the health effect of cooking indoor as against outdoor in the study area.

Materials and Methods

Study area

Nigeria, which is the study area lies between latitudes 4º 12′ 40.37″ N to 13º51′ 36.50 ″ N of the equator and longitudes 2º 45′ 47.735″ E to 14º42′ 55.123″ E of the Greenwich meridian. She spans over an area of 923,768 sq. km (356,669 sq mi), extending 1,127 km (700 mi) East to West and 1,046 km (650 mi) North to South. A country of 36 states and a projected population of 214, 312, 387 at the end of 2019 (NPC, 2006).

Sources of data

This study utilizes 2018 Demographic and Health Survey (DHS) for Nigeria by National Population Commission (NPC) and International Classification of functioning (ICF, 2018) which considered a sample size of 40,680 households out of

which 16,685 households with infants were considered for the study. A total of 9,695 households cooked indoor while 6990 households cooked outdoor. Other relevant information collected in the survey include, the household's socioeconomic factors, pattern of energy used based on percentage, household wealth index and children's health condition based on households that used fuelwood in indoor and outdoor kitchen location.

Model specification and method of estimation

Descriptive statistics

Descriptive statistics was used in describing the characteristics of the data sets through the use of frequencies, mean and standard deviation. Hence, presents the socio-economic factors of the household heads and their respiratory symptoms.

Tobit regression

Tobit model was used in the study to explain the relationship between a non-negative dependent variable (cooking with fuelwood), and independent variables (health symptoms of infants). Based on the assumption that there is a latent variable which linearly depends on the independent one through a parameter (beta) that determines the relationship between the independent and latent variables. The Tobit model is estimated as

$$y_i^* = \beta^t x_i + e_i \qquad i = 1,2,\ldots,n \qquad (1)$$

$$y_i = y_i^* = \begin{cases} y_i = y_i^* \; if \; y_i^* > 0 \\ y_i = 0 \; if \; y_i^* \leq 0 \end{cases}$$

Where: e_i Random error, the set represents all the variables is non observed influencing in the dependent variable y_i^* distributed $y^* \sim N\ (0, \sigma^2)$.

y_i^*: Represents (Latent variable) it is generated through traditional linear regression model according to the formula; ($I_i = \beta^t x_i$) it is non-observable when $y_i^* < 0$.

y_i: Is the independent variable and x_i: the dependent variable known each i=1, 2…, n. Generally, it can be defined as follows:

$$y_i = \begin{cases} \beta^t x_i + e_i \; if \; RHS > 0 \\ 0 \; o.w \end{cases} \qquad (2)$$

β^t = Constant, e_i= error term and *RHS= Right hand side of the equation*

Thus, the model assesses the effect of cooking with fuel wood on infants using Tobit regression analysis.

Logistic model

The dependent variable is dichotomous (subjective) whereby the value of 1 is given to a household that cooks outdoor and 0 for cooking indoor. Estimated coefficients measure the estimated change in the logit for a one-unit change in the predictor variable. A positive estimated coefficient implies an increase in the likelihood that a household would cook outdoor. A negative estimated coefficient indicates that there is less likelihood that a household will cook outdoor but indoor. P-value indicates whether or not a change in the predictor significantly changes the logit at the acceptance level. If p-value is greater than the accepted confidence level, then there is insufficient evidence that a change in the predictor affects the choice of response category.

Hence, binary logistic regression procedure was used to determine the effect of cooking outdoor as against indoor on the health of infants in Nigeria. The equation is presented in this form

$$\ln [p/(1-p)] = \alpha + \Sigma (\beta_k) (X_k)$$

Where: p is the probability that a household cooks outdoor. p/(1-p) is the odds that a household cooks indoor α is a constant term, β_k represents the effects parameters of the explanatory variables, and X_k represents the explanatory variables in the model. Coefficients in a logit model give the change in the log-odds of cooking outdoor for a unit change in the explanatory variables.

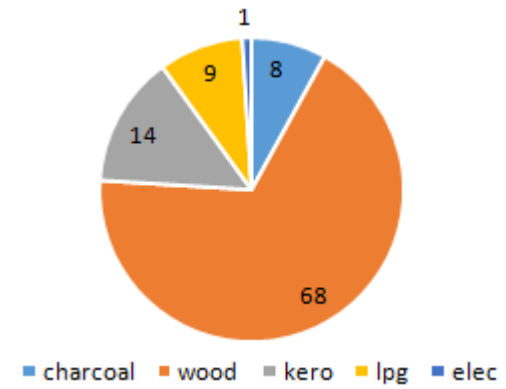
The socio-economic characteristics of the households with infants

This study examines the socio-economic factors of households with infants in Nigeria and the pattern of energy used. Table 1 and Fig. 1 present the results, respectively.

Table 1: Socioeconomic factors of households with infants

Variables	Frequency	%	Mean	St. dev
No of infants per household				
1-2	161848	97	2	1.1
3-4	5006	3		
Sex of household head				
Male	150169	90		
Female	16685	10		
AGE of household head				
18-30	33371	20	43	13
31-43	65073	39		
44-56	41714	25		
57-69	18354	11		
>=70	8343	5		
Wealth index				
Poorest	41714	25	-33811	-42271
Poorer	40045	24		
Middle	35039	21		
Richer	31702	19		
Richest	20022	12		
Place of Cooking				
Indoor	86764	52		
Outdoor	80090	48		
Respiratory Symptoms				
Cough	56730	34	1	0.1
Shortness	55062	33	1	0.1
Blocked Chest and Nose	53393	32	1	1.2

Source: Computed by the Authors' from DHS (2018)



Source: DHS (2018)

Fig. 1: Pattern of household energy used fuel based on percentage

The results revealed that most households have a mean value of two infants per household which constitute 97% of infants in households in Nigeria. Based on the literature, more number of infants in a household that cook with fuelwood, the more the health implications (Rinne *et al*., 2007). Thus these age groups have usually been carried on their mother's back are intensively exposed to the smoke emanating from cooking with fuelwood. Hence, increasing their susceptibility to respiratory symptoms. This is affirmed by the study of World Health Organization (WHO, 2018). Similarly, Table 1 shows that 90% of the household heads were male. It means male

gender dominates the household head position in Nigeria. A similar classification was reported for Nigeria by Maina *et al.* (2019). The households in most zones of Nigeria are polygamous; this shows the likelihood of having more infants in a household where there are more than one wives. Also, the household head is often in charge of taking financial decisions of the household, and this implies the more the number of people in the household the more the financial burden on him and the chance of chosen fuelwood, a cheaper energy choice which is often time at no cost of fetching in Nigeria. Furthermore, given the relatively low cost or no cost of this fuel, the household head would prefer to choose wood as the fuel to be used in his household for cooking. Thus, affordability would be chosen over comfortability of the energy type even if it has high health implication.

The Age of Household Head has a mean of 43 years. It shows that about (39%) of the respondents are in their active age range identified by Maina (2018). It implies that the household heads could support in fetching wood in their farms, nearby bushes as shown by National Bureau of Statistics (NBS, 2019) as a source of fuel to be used for cooking in their households. Moreover, the wealth classification index shows that about 29% of the households in the study area are in the poorest quartile with the mean wealth index of negative ₦33,811. This result reflects the poverty status and wealth inequality situation in Nigeria as reported by (Maina *et al.*, 2019). Wealth status is also a determinant of effective demand. The higher and positive the wealth index, the more the households could afford other energy sources that have less health implication, as proven by the energy ladder model (Maina, 2018). However, the prevalence of low wealth index among the household heads suggests less income to opt for dirty energy source, which is cheaper or at no cost, resulting in more health implications.

With regards to the place of cooking food, the result shows that about 52% of the households that cook with fuelwood do it in an indoor space. It has some health implication because the location of the kitchen where food is cooked with fuelwood determines the health effects on the infants that are usually carried by their mothers on the back while cooking, has reported by Edwards & Langpap (2012). Thus, cooking in an unventilated space holds more pollutant, and that affects all those who are close by which includes the infants. Furthermore, the typical respiratory ailments reported by the households include cough, which has the highest frequency of 34% followed by shortness of breath 33% then blocked nose and chest 32%. These coincide with the known health implications associated by biomass fuel reported by (Kurmi *et al.*, 2014; Desalu *et al.*, 2010; Alim *et al*., 2014).

With regards to the pattern of energy used by households, figure one presents the results.

As can be seen from Fig. 1, Fuelwood is the most used cooking energy with about 68% in Nigeria; followed by the kerosene with about 14%, LPG 9%, then charcoal 8% while electricity was only 1%. The low use of electricity for cooking could be attributed to the fact that its supply over the years has been unsteady in the country (Maina, 2018). Thus, the households have resorted to other means of fuels for cooking. Increase in the use of fuelwood could result in high health implication on the household members, especially women and infants, who go close to it while cooking (Dionisio *et al*., 2008).

The Effect of cooking with fuelwood on the health of infants

The study assessed the effect of cooking with fuelwood on the health of infants using Tobit regression analysis. Table 2 presents the results.

The results in Table 2 show that the coefficient of cough is negatively related to cooking with fuelwood among infants. It implies that the lesser the number of infants in a household that cooks with fuelwood the lesser the health symptoms of cough among this age group. Therefore, as the infants grow up, they are no longer taken close to the place such pollutants are emitted. The result further shows that a 1% reduction in the number of infants in a household that uses fuelwood it would reduce cough by 3%. It is in line with the result of Regalado *et al.* (2006). However, the coefficient was an insignificant determinant of health implication of cooking with wood fuel, although it was reported in table 1, with the highest frequency of (34%). It could be because some cough symptoms are a bacterial infection caused by purulent bronchitis, as reported by Zgherea *et al*. (2012).

Furthermore, the coefficient of shortness of breath is positive and is significant at 1%. It implies that the more the number of infants in a household cooking with fuelwood, the more they are affected by shortness of breath. 1% increase in the number of infants in a household it would increase the incident of shortness of breath by 41%. It corresponds with the findings of Edwards & Langpap (2012), indicating that more use of fuelwood It household raises the probability that a child has shortness of breath. Similarly, the coefficient of block chest and nose is negatively related to cooking with fuelwood and is significant at 1%. It signifies that the lesser the number of infants in a household that cooks with fuelwood, the lesser the health implication of blocked nose and chest has been reported. It means that a 1% decrease in the number of infants in a household that cooks with fuelwood, it will reduce the symptoms by 27%. The result is justified by Dionisio *et al*. (2008) who opined that the lesser the number of infants who spend time close to their mothers throughout the day, including being carried on the mother's back the lesser the health implication. Considering the magnitude of the t values, the ailments shortness of breath affects infants more followed by blocked nose and chest reduces.

Table 2: Health effect of cooking with fuelwood on infants

Variable	Coefficient	Standard error	T value	p>[t]
Constant	0.498	0.202	2.46	0.014**
had cough	-0.627	0.207	-0.3	0.761^{NS}
shortness of breath	-0.209	0.005	-4.11	0.000***
blocked chest and nose	-0.052	0.019	-2.72	0.007***
F- value	8.57			
Prob	0.000***			

Note: ***, **, indicates parameter significance at α= 1% and 5% respectively while NS= not significant

Table 3: The effect of cooking location on the health of infants

Variable	Coefficient	Standard error	T value	p>[t]
Constant	-0.223	0.193	-1.15	0.249^{NS}
had cough	-0.123	0.204	-0.6	0.545^{NS}
shortness of breath	-0.125	0.059	-2.08	0.003***
blocked chest and nose	-0.019	0.001	-2.58	0.001***
f value	4.32			
Prob >f	0.004***			

***, **, indicates parameter significance at α= 1% and 5% respectively while NS= not significant

The effect of the cooking location on the health of infants

Various literature works have qualitatively asserted that the location of placing kitchen indoor, for household that uses fuelwood has more health effect than the outdoor. This study has therefore assessed the observed variation between such two locations using inferential statistics, that was used to determine the extent of the variation based on the extracted data from the DHS 2018. Table 3 presents the results

The coefficients of the respiratory symptoms in Table 3 are all negatively related to the health of infants. However, the

ailment cough is not a significant determinant of cooking with fuelwood at an indoor or outdoor kitchen location. While shortness of breath and blocked nose and chest are significant determinants both at the 1% level. It implies that *ceteris parabus*, when food is cooked with fuelwood in an indoor kitchen, it would significantly affect the infants. 1% decrease in cooking indoor would reduce blocked chest and nose by 25%, shortness of breath by 20% and cough by 6%. It is in line with the findings of (Edwards & Langpap, 2012) whose results provided justifications that cooking inside the home increases the probability of infants having symptoms of a respiratory infection.

Conclusion

Majority of the households have infants, and the economic status of the household heads' based on their wealth index is poor. The primary source of energy is fuelwood which is used for cooking mostly in an indoor kitchen. The significant respiratory symptoms that affect the infants are shortness of breath and blocked nose and chest. Cooking in an indoor kitchen has a high effect on the health of the infants than an outdoor location.

Recommendation

1. The effects of fuelwood use are statistically significant on the respiratory health of infants. Hence, the government should intensify its efforts to produce an improved biomass cooking stove that uses fuel efficiently and emits less pollutants. They should be made easily assessable by giving high priority to the local needs of the households.
2. Government should promote a policy that imposes the installation of smoke extractors in various kitchen location to reduce the smoke exposure by the household.
3. Also, there is a need to create more awareness, especially among women with infants on the dangers of exposing them to cooking smoke. It could be achieved through the media, outreach and health awareness campaigns.

Conflict of Interest

The authors declare that there is no conflict of interest related to this study.

References

Alim MA, Sarker MAB, Selim S, Karim MR, Yoshida Y & Hamajima N 2014. Respiratory involvements among women exposed to the smoke of traditional biomass fuel and gas fuel in a district of Bangladesh. *Environ. Health Prev. Med.*, 19: 126–134.

Brunekreef B & Holgate ST 2002. Air pollution and health. *Lancet*, 360: 1233–1242.

Demographic Health Survey 2018. https//dhsprogram.Standard-DHS_2018.cfm?flag=0.

Desalu OO, Adekoya AO & Ampitan BA 2010. Increased risk of respiratory symptoms and chronic bronchitis in women using biomass fuels in Nigeria. *J. Bras. Pneumol*., 36: 441–446.

Dionisio K & Adegbola R, 2008. Measuring the exposure of infants and children to indoor air pollution from biomass fuels in the Gambia indoor air 18: 317–327.

Edwards YHJ & Langpap C 2012. Fuel choice, indoor air pollution and children's health. *Envt. and Devt. Econ.* 17: 379–406.

FAO 2019. Nigeria: Woodfuel Supply and Energy Demand Assessment 2013–2018 Format https://reliefweb.int/report/nigeria/nigeria-borno-state-woodfuel-supply-and-energy-demand-assessment-2013-2018

Kurmi OP, Semple S, Devereux GS, Gaihre S, Lam KBL, Sadhra S, Steiner MF, Simkhada P, Smith WC & Ayres JG 2014. The effect of exposure to biomass smoke on respiratory symptoms in adult rural and urban Nepalese populations. *Environ. Health*, 13: 92. doi:10.1186/1476-069X-13-92.

Levy RJ 2015. Carbon monoxide pollution and neurodevelopment: A public health concern. *Neurotoxicology and Teratology*, 49: 31-40.

Lidia M & Junfeng Z 2002. Combustion sources of particles. Health relevance and source signatures. *Chemosphere*, 49: 1045–1058.

Maina, Y. B. 2018. An empirical analysis of household energy demand and the negative externality of carbon dioxide (CO2) emission in northeastern Nigeria. An unpublished Ph.D. Thesis submitted to the Postgraduate school, in fulfillment for the award of the Degree of Doctor of Philosophy in Economics Usmanu Danfodiyo University, Sokoto, Nigeria.

Maina YB, Kyari BG & Maina MB 2019. Households' clean energy demand in Nigeria and its implication on the environment. *J. Agric. Econ., Envt. and Soc. Sci.*, 5(1 & 2): 35-55.

McFadden D 1973. Conditional Logit Analysis of Qualitative Choice Behavior.

National Bureau of Statistics. 2019. *General Household Survey Panel Wave 4*. (2018/19). Retrieved from http://www.nigeriastat.gov.ng>STATAuploads.

National Family Health Survey Bulletin 1997. Cooking Smoke Increases the Risk of Acute Respiratory Infection in children. International Institute for Population Sciences Mumbai. Online http://rchiips.org/nfhs/research1.htmlNFHSBulletinNo.8(1997)

Regalado J, Sarker MA, Selim S, Karim MR, Yoshida Y & Hamajima N 2006. The effect of biomass burning on respiratory symptoms and lung function in rural Mexican women. *Am. J. Respir. Crit. Care Med.*, 174: 901–905.

Rinne TS, Rodas JE, Rinne LM, Simpson MJ & Glickman TL 2007. Use of biomass fuel is associated with infant mortality and child health in trend analysis. *The Am. J. Trop. Med. and Hygiene*, 76(3): 585–591.

Samuel GW, Ajayi MP, Idowu AE & Ogundipe O 2016. Levels and trends in household's source of cooking fuel in Nigeria: implications on under-five mortality. *Health Sci. J.*, 10(4): 1-5.

Tilasto 2018. Fuelwood, Consumption by Households in Nigeria. Online: https://www.tilasto.com/en/topic/energy-and-environment/fuelwood/consumption/fuelwood-consumption-by-households/nigeria

UNDP-WHO 2009. United Nations Development Programme and World Health Organization. *The Energy Access Situation in Developing Countries*, New York.

World Bank., 2018. Nigeria Economic Report, Improved Economic Outlook in 2019, and prospects for continued growth look good Online: https://www.worldbank.org/en/country/nigeria/publication/nigeria-economic-report-improved-economic-outlook-in-2018-and-prospects-for-continued-growth-look-good.

World Health Organization., 2004. 'Indoor Smoke from Solid Fuels', Comparative Quantification of Health Risks: Global Burden of Disease Due to Selected Major Risk Factors, *Geneva*, pp. 1435–1493.

Zgherea D, Pagala S, Mendiratta M, Marcus MG, Shelov SP & Kazachkov M 2012. Bronchoscopic findings in children with chronic wet cough. *Pediatrics*, 129(2): pp. e364-e369.