EFFECT OF HOUSEHOLDS' PRIMARY COOKING FUEL ON INFANT'S ACUTE RESPIRATORY INFECTION IN NIGERIA

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Abstract
Acute Respiratory Infection (ARI) has been identified as a major global burden of disease and a dominant cause of under-5 mortality in Nigeria. Oxidative stress and irritations in respiratory tracts are linked to toxic emission from household cooking with unclean biomass fuels. Yet, the extent to which individual polluting fuels explain the prevalence of ARI among under-5 children in Nigeria is unclear. This study therefore adopts a disaggregated-fuel approach to examine the contributory role of household cooking fuels on the prevalence of ARI in Nigeria. It uses the 2018 Demographic and Health Survey data and employs a Logistic Regression model to examine the fuel-ARI link among under-five children in the country. The result suggests that 91% of children in homes cooking with unclean fuels experience ARI while barely 8% reported the same in clean cooking households. Also, cooking with firewood and strew was significantly linked to ARI, while other factors such as maternal education, household wealth and place of residency equally predicted ARI prevalence among under-5 children. The study recommends the need for policies targeted towards up-scaling the deployment of improved cooking stoves among rural, biomass cooking households in country.

Keyword: *Acute Respiratory Infection, cooking fuel, household, Nigeria*

1. Introduction

Primary cooking fuels are various forms of energy providing heat and light for cooking, through the process of combustion. These can be classified into two - the modern and traditional. Households in the modern category are those that use either electric stoves or gas cookers as their main cooking fuel. This category is also known as clean fuel. However, those in the traditional or unclean fuel category constitute households that utilize either firewood, straw, dung, charcoal, or kerosene as primary cooking fuel (World Health Organization, WHO, 2019; 2020). The use of traditional cooking fuels in households is associated with increased deaths (Churchill and Smyth, 2020). This is based on the fact that oxidative stress and irritations in respiratory tracts are connected to toxic emission from household cooking with unclean biomass fuels. Indeed, the

traditional cooking fuels and Acute Respiratory Infection (ARI) are closely linked. For instance, the infant vulnerability to ARI from unclean fuels depends on the level of pregnant woman's exposure to toxic gasses emitted from polluting cooking fuels, which in turn determinants the health of infants when they were born (WHO, 2019). Similarly, the use of unclean cooking fuels is positively associated with both physical and cognitive development of infants (Islam and Mohanty, 2021).

The largest contributors to mortality among infants worldwide are Acute Respiratory Infections, followed by diarrhea diseases and neonatal complications (World Health Organization, WHO, 2020). Although the world has made substantial progress in child survival since 1990; attributed to the United Nations' Millennium Development Goals (MDGs) that ended in September, 2015. For instance, the global number of newborns deaths dramatically reduced from 65 deaths per 1,000 infants in 1990 to 29 per 1,000 in 2018 (World Bank, 2021). The share of infant deaths is also still relatively low in Europe and North America as the number of infant mortalities declined from 9 to 3 deaths and 10 to 5 deaths in every 1,000 infants, respectively.

However, the number of infants experiencing Acute Respiratory Infections are rising in developing countries. There are approximately 7,000 newborn deaths every day in these nations, amounting to 47% of all child deaths under the age of 5-years, up from 40% in 1990 (WHO, 2020). It is worthy of note that, five nations (India, Pakistan, Nigeria, Democratic Republic of Congo and Ethiopia) alone accounted for half of the global infant deaths in 2018. In Nigeria, the largest economy in Africa, 9% of global infant deaths are contributed from the nation annually (WHO, 2019). This makes the country the third largest contributor to new-born mortalities in the world. Compared to Ghana and South Africa's indices of 34 and 41 deaths in every 1,000 infants in 2018, respectively, the infant mortality rate is still relatively higher in Nigeria with 67 deaths per 1,000 infants (World Bank, 2021).

The majority of these deaths are attributed to domestic air pollution (UNICEF, 2019) dominantly coming from cooking with unclean fuels such as firewood, charcoal, strew, and animal dung. Preventing the exposure of infant and pregnant women from biomass emission would not only contribute to improving their health outcomes, but also minimize household expenditure on healthcare. In addition, this would also result in lesser burden of global diseases such as diabetes, lung cancer and cardiovascular attacks, as these diseases are connected to exposure to pollution at infant stage. Importantly, healthy children are *central to future economic progress since a healthy workforce is paramount for economic productiveness through fewer days off work and increased output per labor hour. Though previous works have studied the effect of cooking fuels on child's ARI prevalence (*Mondal and Paul, 2020; Mulugeta and Yadeta, 2020; Andualem, Azene, Dessie, Dagne and Dagnew, 2020) *these works nonetheless* broadly classify cooking fuels into clean and unclean and therefore consequently miss out important specific details regarding the contribution of each fuel type in explaining ARI prevalence in children. *This is however important for* understanding the dominant drivers of ARI and in ensuring more policy targeted interventions.

This gap forms the motivation for this study which aims to investigate the probable *effects of* household primary cooking fuel on infant's Acute Respiratory Infection in Nigeria. Results from the study revealed that cooking with firewood and strew was significantly linked to ARI, while other factors such as maternal education, household wealth and place of residency equally predicted ARI prevalence among under-5 children. The rest of the paper is organized as followed: section one is introduction, section two

focuses on literature review, and section three discusses the methodology. Section four and five respectively analyzes the findings and concludes the study.

2.0 LITERATURE REVIEW

Access to electricity has become an important issue of concern in Nigeria and this is because it has far-reaching implications for quality of life and health in society. Nigeria is the largest country in Africa in terms of population and thus has the highest healthcare demand and energy needs (World Bank, 2021). Although Nigeria is an exports energy products like electricity to Benin, Togo and Niger, the country is yet to achieve full electricity coverage nationwide.

Table 1 indicates that the number of Nigerians with access to electricity in 2017 is 54.4% which is quite low relative to regional peer countries like Ghana and South Africa who record 79% and 84%. Visibly, while Nigeria recorded approximately 12 percentage-point increase in access to electricity between 2000 and 2017, Ghana, Kenya and Cameroon recorded percentage-point increments of 35.3%, 48.5%, and 20.4%, respectively. This indicates that access to clean cooking energy is a growing concern that needs to be addressed if the country is to achieve sustained growth and development. These indicators suggest that nearly half of the Nigeria's population (45.6%) dwell in darkness and this has severely constrained productivity and aggravated the already poor health outcomes in the country. The generation, transmission and distribution of electricity in Nigeria have over the years been suboptimal.

Table 1: Access to Electricity (% of population)

	2000	2005	2010	2015	2016	2017
Nigeria	42.7	47.2	48.0	52.5	59.3	54.4
South Africa	71.7	80.9	82.9	85.5	84.2	84.4
Ghana	43.7	54.6	64.2	75.9	79.3	79.0
Kenya	15.3	26.0	19.2	41.6	65.4	63.8
Egypt, Arab Rep.	97.7	99.4	99.6	100.0	100.0	100.0
Cameroon	41.0	47.3	53.1	58.8	60.1	61.4
Sub-Saharan Africa Average	26.0	29.9	33.6	39.4	44.8	44.6
World Average	78.4	80.2	83.3	86.8	88.0	88.8

Source: World Bank, World Development Indicators, 2021

Another dimension of Nigeria's energy deficit is the country's low access to clean fuels and technologies for cooking (% of population). Table 2 shows that only 4.91% of Nigerians have access to clean fuels and technologies for cooking in 2017. Nigeria's is a major crude oil exporter and has the largest natural gas reserves in Africa; yet between 2000-2016 the country's population with access to clean fuels and technologies has remained consistently below 5% compared with regional peer countries that are recording double digit figures.

Table 2: Access to Clean Fuels and Technologies for cooking (% of population) in Africa

	2000	2005	2010	2015	2016
Nigeria	0.84	1.39	2.44	4.39	4.91
South Africa	56.43	67.53	76.65	83.64	84.75
Ghana	5.89	9.44	14.05	20.37	21.71
Angola	37.27	40.75	44.10	47.36	48.05

Kenya	1.99	4.28	8.02	12.76	13.42
Egypt, Arab Rep.	83.28	91.98	95.99	97.31	97.62
Cameroon	9.88	13.50	17.60	21.98	23.04
Sub-Saharan Africa Average	9.29	10.70	12.26	14.02	14.39
World Average	49.41	52.67	56.07	58.84	59.34

Source: World Bank, World Development Indicators, 2021

Comparatively, a higher percentage of the population in Egypt (97.6%) and South Africa (84.8%) have access to clean fuels and modern technologies for cooking compared with Nigeria's 4.91% in 2016. These numbers reflect the appalling energy situation (crisis) in Nigeria and remains a paradox. Despite its abundant energy resources, widespread access to unclean cooking fuels remains rife as the country struggles with significant infant health challenges.

The literature investigating risk factors associated with ARI is large and expanding. ARI is considered a major global burden of disease and a dominant cause of under-5 mortality in many developing countries in the world. Several socioeconomic and behavioral factors have interestingly been identified as risk factors of ARI in existing works. And household cooking fuel type is considered a dominant factor. Polluting, biomass fuels such as coal, firewood, strew, and charcoal emit health-damaging gasses such as carbon monoxide and Sulphur oxide compared to LPG, electricity, and improved cooking stoves which emit minimal or no harmful gasses. Unfortunately, woman and children disproportionately suffer the brunt from unclean cooking fuels owing to their traditional role as major source of household cooking labor.

Children, especially under-5, in household cooking with polluting fuels, are especially vulnerable to aliment such as ARI as these gasses binds with respiratory tracts, causing oxidative stress and irritations. Empirical studies have therefore established a strong association between cooking fuel types and ARI prevalence among children. For instance, Lamichhane, Sharma and Mahal (2017) showed that compared to household exclusively using polluting fuels, household using LPG, mixed fuels and improved stoves were 5%, 2.9% and 2.8% less likely to report ARI among under-5 children in India. Similarly, Andualem, Azene, Dessie, Dagne and Dagnew (2020) concluded from their meta-analysis of 7 Ethiopian studies that child holding during cooking and the use of unclean cooking fuels were significantly linked to higher prevalence of ARI among under-5 children in Ethiopia. Kilabuko and Nakai (2007) also found that the use of kerosene/charcoal and other biomass heightened the risk of ARI in under-5 children in Tanzania. Similar evidence has also surfaced in India, Nigeria, and Afghanistan (Mondal and Paul, 2020; Adesanya and Chiao, 2016; Sk, Rasooly and Barua, 2019).

Household vulnerability to ARI from unclean fuels depends on their level of exposure to toxic gasses emitted from polluting cooking fuels which in turn depends on household kitchen location as well as the availability or otherwise of emission escapes. Kitchens located in a separate room or outdoor allows for easier escape of incomplete combusted gasses as well as lessen gaseous concentration within dwelling. Studies have shown a close link between household cooking fuel type, kitchen location, and the prevalence of ARI. For instance, Sk et al. (2019) found that compared to household using clean fuels in a separate room, households using clean fuels within the house and without a sperate room were 32% and 17% less likely to report children with ARI. Furthermore, household using polluting fuels without a kitchen as well as those cooking in a separate kitchen had a 14% and 5% higher likelihood of ARI prevalence. Similarly, Geremew, Gebremedhin,

Mulugeta and Yadeta (2020) showed that Afghanistan household cooking indoors were 44% more likely to report ARI compared to those cooking outdoor. Mondal and Paul (2020) concluded that household using biomass without a separate room as kitchen were 36% more likely to report ARI in children living in India compared to those with a separate kitchen for cooking.

In addition to cooking fuel and kitchen location, studies have usually controlled for likely confounding factors that may explain ARI prevalence among under-5 children. While these studies reveal important insights on ARI risk factors, their conclusions have been mixed. Factors such as household income, usually proxied by household wealth index, for example have produced mixed result. Mondal and Paul (2020) and Adesanya and Chiao (2016) studied the role of household income in explaining ARI prevenance in India and Nigeria respectively and concluded that income was insignificant in explaining the prevalence of ARI among under-5 children in both countries. Contrary to their findings, Sk et al. (2019) and Lamichhane et al. (2017) found that household income significantly explained ARI prevalence among under-5 children in India and Afghanistan respectively. Other factors such as maternal education, child birth position, and household residency (urban or rural) have consistently predicted ARI across various studies in the literature. Higher levels of maternal educational qualification were found to significantly correlate with decreasing prevalence of ARI in households (Adesanya and Chiao, 2016; Lamichhane et al., 2017; Sk et al., 2019). Furthermore, children in third or higher birth position showed higher likelihood of ARI compared to those that came earlier (Mondal and Paul, 2020; Adesanya and Chiao, 2016; Sk et al., 2019). Also, children from rural household tend to be at greater risk of ARI compared to those in the urban sector (Andualem et al., 2020; Seidu, Dickson, Ahinkorah, Amu, Darteh and Kumi-Kyereme, 2019). Absence of improved toilet and water facilities, maternal tobacco smoking habits, maternal age at child birth, and child's gender and age as well as households' history of underlying illness have also been studied. Their evidence is however far from conclusive and remain highly context-specific.

Collectively, the extent literature reviewed uncovers insightful findings and deepens understanding of associated risk factors of ARI. However, it is still unclear the effect of individual cooking fuel type on ARI among under-5 children as most studies broadly classify these fuels under-polluting, clean or unclean fuels. While this broad classification provides a bigger picture of the fuel-ARI nexus, they obscure important specific details regarding the contribution of each fuel type in explaining ARI prevalence in children. In addition, some of these studies have arguably misclassified fuels like kerosene under clean fuels. Recent evidence now shows that kerosene emits as much toxic gas as other biomass fuels (Kilabuko and Nakai, 2007). Besides, studies on the effect of household cooking fuel on under-5 ARI for Nigeria are scanty and mostly belated. For example, Adesanya and Chiao (2016) used the 2013 Nigerian DHS data to study the socioeconomic factors that determining ARI among children in Nigeria. While their findings interestingly identified several important risk factors of ARI, household's socioeconomic status and profile have expectedly changed over the years and therefore changed the likelihoods of these factors and their potential risk profile on child's ARI ailment.

From the foregoing gap in the literature, this study therefore aims to study the effect of individual cooking fuels such as kerosene, charcoal, wood/strew and electricity/LPG on the prevalence of ARI in under-5 children in Nigeria. This is important for understanding

the specific and dominant drivers of ARI within the broad fuel classification adopted in previous studies and for promoting more policy targeted intervention. In addition, the study uses the latest 2018 DHS data; providing evidence that more closely reflect current trends on the fuel-ARI nexus in Nigeria.

3.0 METHODOLOGY

3.1 Model Specification

This study uses a bivariate logistic regression model to examine the effect of household cooking fuel on the prevalence ARI among under-5 children in Nigeria. These group of models have been widely used in the literature and remain especially handy in estimating economic relations characterized with a binary response variable. The dependent variable, in this study is binary: carrying the value of 1 if a household report a case of ARI and 0 otherwise.

Algebraically this relation is defined as:

(1)

(2)

From Eqn. 1, is the probability that a household report an ARI case, carry the values of 1 or 0. is a vector of conditional determinant that explains the probability distribution function of . In Eqn. 2, represent the intercept term while is the regression coefficient to be estimated for variable , which are the predictors of the outcome variable in the model. Variables that are captured within the X vector include household cooking fuel types, maternal highest educational qualification, household wealth index, and household residential sector.

3.2 Data Source and Description

The 2018 Demographic and Health Survey data for Nigeria was used. This nationally representative survey data is collected by the country's National Population Commission in collaboration with the National Malaria Elimination Program and funded by several international agencies including the World Health Organization. The selection of sample household was based on a stratified, two-stage cluster design. 1, 400 enumeration area were identified in the first stage. The second stage involved listing roughly 42,000 households made up of women and men within the age of 15-49 and 15-59 respectively, randomly selected across the four geopolitical zones country. Comprehensive data on household socioeconomic, health, and cooking fuel data were collected, weighted and reported. The data is freely available on the World Bank micro data catalog.

4.0 RESULT AND DISCUSSION

Table 3 present the summary statistics based on two households' classification of primary cooking fuel. Household in the clean fuel category are those that use either electric stoves or LGP as their primary cooking fuel. While those in the unclean fuel category constitute households that utilize either firewood, straw, dung, charcoal, or kerosene as primary cooking fuel. The frequency columns summarize the number of individual households that fall within each fuel-use category along the corresponding variables, while their respective relative percentage shows the fraction of these variables relative to their fuel category.

Table 3. Descriptive statistics

	CLEAN FUEL	UNCLEAN FUEL

Variables	Frequency	Relative %	Frequency	Relative %
Acute Respiratory Infection (No. of Under-5 children reported)				
No	2,311	8.15	26,047	91.85
Yes	91	4.95	1,749	95.05
Maternal highest educational qualification (No. of women)				
No education	65	2.57	15,228	49.21
Primary	150	5.92	5,057	16.34
Secondary	1,160	45.80	9,238	29.85
Higher	1,158	45.72	1,424	4.60
Household wealth index (No. of households within index category)				
Poorest	11	0.43	7,338	23.71
Poorer	70	2.76	7,177	23.19
Middle	249	9.83	6,599	21.32
Richer	573	22.62	5,807	18.76
Richest	1,630	64.35	4,026	13.01
Neonate birth position (No. of surviving birth)				
Parity (1– 3)	1,926	76.04	15,622	50.48
Parity (4 – 6)	515	20.33	10,005	32.33
Parity (>6)	92	3.63	5,320	17.19
Household residential sector (No. of resident households)				
Urban	2,063	17.92	9,450	82.08
Rural	470	2.14	21,497	97.86

Source: NDHS (2018)

For instance, of the total number of households that declare no case of ARI, 8.15% fall under the clean fuel category while the remaining 91.85% were from the unclean category. Similar interpretation applies to the remaining case.

Table 44. Logistic Regression Result

Variables	AOR (S.E)
Cooking fuels	
Electricity/gas	Reference
Wood/Straw	0.2256*(0.1247)
Charcoal	0.1163 (0.1616)
Kerosene	0.0081 (0.1482)
Maternal highest educational qualification	
No education	Reference
Primary	0.3274***(0.0699)
Secondary	0.2296***(0.0703)
Higher	0.1979 (0.1256)
Household wealth index	
Poorest	0.6443***(0.1049)
Poorer	0.5318***(0.0996)
Middle	0.2841***(0.0972)
Richer	0.2412**(0.0935)
Richest	Reference
Neonate birth position	
Position (1– 3)	0.0604(0.0721)
Position (4 – 6)	-0.0006(0.0750)
Position (>6)	Reference
Household residential sector	
Urban	Reference
Rural	0.3995***(0.0639)
Constant	-3.7444***(0.1537)
Robustness statistics	
Wald chi2(13)	127.57
Prob > chi2	0.0000
Pseudo R2	0.0107
Number of Obs.	30,198

Source: Author Using Stata 14. *,**,*** indicate statistical significance at 10%, 5%, and 1% respectively.

The statistics preemptively suggest that household whose primary cooking source is unclean fuel are more susceptible to experience Acute Respiratory Infection compared to other households using clean fuel sources. This generalization is however not true for otherwise similar development indicators. For instance, the table shows unclean-fuel households constitute the majority of household without any formal education. The same category of fuel users equally contains the majority of households with higher education. However, because the sample size of each group is not the same, caveat should be applied when interpreting the results. The overall number of households within the unclean-fuel group are significantly higher than those in the clean fuel group. Therefore, neither the frequencies nor relative percentage should be understood in absolute terms.

Table 4 shows the estimated logistic regression result. Compared to electricity/gas cooking, households cooking with wood/straw have higher odds of reporting acute respiratory infection. This is unsurprising as incomplete combustion resulting from firewood cooking dominantly account for carbon monoxide emission which binds with

respiratory tracts to cause diseases such as ARIs. Household income, measured by their wealth index, turned out to significantly but regressively explain the likelihood of acute respiratory infection. For example, compared to richest households, poorest and poorer household show higher odds of having acute respiratory infection. Of course, with higher incomes, household can afford more efficient cooking fuels as well as spacious kitchens that allows for better ventilation and thus lesser concentration of any toxic gas from cooking fuels. However, unlike other studies, the results shows that neonate birth position turned out not to significantly explain ARI prevalence among under-5 children.

Interestingly, maternal highest educational qualification appears to be an important determinant of ARI. Compared to those with degree and above, mothers with progressively higher educational qualification are increasingly less likely to report children with ARI. This result follows from two possible channels. Firstly, higher maternal educational qualification can imply higher income earning potentials. Secondly, with better education comes more knowledge about the harmful effect of polluting cooking fuels; encouraging caution to minimize infant's exposure. In contrast to households residing in urban areas, rural-based households show more likelihood of reporting ARI prevalence in under-children. Wide-spread biomass use dominantly characterize rural household cooking fuels. For one reason, most household are unable to afford and/or access cleaner and more efficient stove. For another, cultural inertia that involves traditional cooking styles appears to be strongest among rural dwellers.

To the extent that this study reveals that cooking fuels such as biomass are important risk factors of ARI among under-5 children, the findings corroborate those of Adesanya and Chiao (2016), Sk *et al.* (2019) and Sharma and Mahal (2017). Also, like the works of Andualem *et al.* (2020) and Seidu *et al.* (2019), the study reveals that other maternal and environmental factors interestingly explain a significant part of ARI prevalence in children. However, the study is unable to show evidence for how the individual cooking fuel interact with kitchen sizes and location as explored by Geremew *et al.* (2020) nor how factors such as maternal health outcomes, smoking behavior or household underlying illness predict ARI in children (see Mondal and Paul 2020; Adesanya and Chiao, 2016; and Sk *et al.,* 2019). Nonetheless, it deepens understanding of the specific fuel types significantly associating with ARI prevalence and therefore allows for more targeted households cooking fuel intervention in the country.

5.0 CONCLUSION AND POLICY RECOMMENDATIONS

Worldwide and especially in the global south, infant mortalities are dominantly attributed to Acute Respiratory Infections, diarrhea and other neonatal health challenges. Nigeria, being among the five nations that account for 50% of global infant death and the highest reporter of under-5 mortality in the Africa subregion represents an interesting but important case study for investigating the ARI prevalence. Solid fuels are major source of toxic carbons which are deleterious to human health, especially infants. These fuels unfortunately constitute a significant share of most household cooking fuel portfolio and remain the primary source of cooking fuel for other households in the country. Poor kitchen ventilation in most households in addition to prolonged cooking time, often expose women and children who constitute the major source of household cooking labor to these hazardous gasses and therefore makes them vulnerable to ailment such as ARI, cataract, heart attacks and pregnancy complications resulting from Intrauterine Growth Retardations.

Using the 2018 Nigerian Demographic and Health Survey data and employing a logistic regression model, this study examined the effect of various household primary cooking

fuel types on their likelihood to explain the prevalence of Acute Respiratory Infection among under-five children in the country. The results reveal that compared to household using electricity or gas, household use of firewood and strew significantly predicted the prevalence of Acute Respiratory Infection in the country. Other cooking fuel types such as charcoal, coal, and kerosene did not seem to be a significant risk factor for Acute Respiratory Infection among under-5 children in the country. Nonetheless, socioeconomic factors such as maternal education, household wealth, and location of residency all appeared to explain Acute Respiratory Infection's prevalence among under-5 infants.

The policy implications based on the foregoing findings underscores the need for targeted interventions towards disseminating improved cooking stoves to especially households primarily cooking with firewood and strew. This intervention should be championed by the government in collaboration with organizations such as Global Alliance for Improved Stoves and the World Bank. Flexible payment measures such as spreading repayment over time and granting subsidies should be bundled with such intervention. This would help ensure rapid adoption and in turn reduce the number of under-5 children with ARI symptoms in the country.

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