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PATTERN OF COOKING FUEL USE AND HOUSEHOLD RESPIRATORY HEALTH IN IBADAN, NIGERIA

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Abstract

This aim of this study was to analyse the pattern of cooking fuel use on household respiratory health in Ibadan. Using the survey research design, a sample of 400 household was drawn from Ibadan population. The result of the study showed that cooking fuel choice has important implications for household respiratory health in Ibadan. The use of unclean cooking fuel seems particularly dangerous and is associated with high risk of respiratory health issues. This is mainly related to the use of firewood as its use is associated with the highest incidence of respiratory health challenges according to the study's findings.

Keywords: *Cooking fuel; Indoor air pollution; Respiratory health.*

INTRODUCTION

The health implication of heavy cooking fuels has been well outlined in the literature (Das et al., 2017; Mahapatra et al., 2019). It has been established that heavy cooking fuels such as kerosene and firewood constitute the major cause of indoor air pollution in the larger part of the developing world, Nigeria inclusive (Mahapatra et al., 2019). These heavy cooking fuels are associated with toxic emissions which have health hazards upon entry into the blood stream (Sukhsohale et al., 2013). As Brauer et al. (2016) asserted, household air pollution from heavy cooking fuel is ranked 7th risk factor for burden of disease globally. They have also been linked to infant mortality rates (Olugbemisola et al., 2016).

As Ali et al. (2019) noted, despite the health hazard associated with their use, the prevalent use of heavy cooking fuels in the developing world can be said to be associated with the high cost of cleaner cooking fuels. Globally, the World Health Organization (WHO) reported that around 3 billion persons used solid fuel (biomass and coal) for heating and cooking with a projected increase up till at least (Mahapatra et al., 2019).

WHO also revealed indoor air pollution as the eighth most important risk factor responsible for 2.7% of the global burden of disease. The health risk of heavy cooking fuels is due to the release of particulates from these fuels that have adverse implications on respiratory health.

The particulates are indirectly formed when gases from burning fuels react with sunlight and water vapour, and during smoking by members of household. In one of the earliest studies Samet (1993) and Samet et al. (2012) examined indoor pollutant sources and related effects on the respiratory health of exposed subjects. The positive association between exposure to particulate matter (PM), air pollution and its adverse impacts on respiratory health has also been investigated (Dominici et al., 2006; Krewski et al., 2005). In recent years, particles less than 2.5μm ($PM_{2.5}$) in aerodynamic diameter has been most strongly associated with adverse respiratory impacts. These are also referred to as "fine" particles and, are an important indicator of indoor air pollution. The small size and structural complexity cause these fine particles to lodge deeply into the lungs, and hence, results in respiratory illness. There is consistent evidence that indoor air pollution increases morbidity and mortality from respiratory tract symptoms in childhood ((Hertz-Picciotto et al., 2007). The respiratory illnesses reported are croup, bronchitis/bronchiolitis, asthma, and pneumonia (Hertz-Picciotto et al., 2007). The permissible 24-hour mean particulate matter level as per the World Health Organization (WHO) guidelines for air quality is $25\mu g/m^3$ for $PM_{2.5}$ and $50\mu g/m^3$ for PM_{10} (particles less than 10μm) which are far below levels associated with emissions from heavy cooking fuels (Kumar et al., 2015).

No doubt, these elevated levels of particulate pollution are associated with increased incidence of respiratory symptoms and diseases including acute lower respiratory infections (ALRI) in household members (Smith et al., 2000), carcinoma of the lungs (Mu et al., 2013; Reid et al., 2012) and exacerbations of bronchial asthma and chronic obstructive pulmonary disease (Parez-Padilla et al., 1996). In addition, epidemiological studies have also linked exposure to indoor air pollution to decreased pulmonary function, increased hospitalisation for respiratory diseases and increased mortality (Bruce et al., 2000).

Given the foregoing, this study examines the patten of cooking fuel use and household respiratory health in Ibadan, Nigeria. The rest of the study is organised as follows. Section 2 gives a brief review of the literature while and an overview of household cooking fuel choices. Section 3 outlines research methods while section 4 presents results of empirical analysis. The study concludes in section 5 with summary and recommendations.

REVIEW OF LITERATURE

Traditional Cooking Fuel Choices

Animal dung

Dung is defined as the undigested excrement of herbivorous animals, or what remains after the plant stuff has been eaten up and gone through the animal's intestines. Cattle, goat, sheep, yaks, elephants, llamas, and other animals' excrement are all common cooking fuels because they contain large amounts of pre-processed comparatively tiny biomass from shrubs, straw, and grass.

For energy, more than 2 billion people in the earth burn dried animal dung (Toklu, 2017). Dung is a frequently utilized fuel source, especially among poor-income households, because it is freely gotten and accessible without charge. Dung is also a typical source of fuel in locations where there is scarcity of wood. As a result, dung provides a useful condensed pre-processed fuel in dry or cold climates where woody trees are scarce (e.g., Tibet, Mongolia, high areas of the Andes, etc.). Dung is gathered from grasslands with unrestricted domestic or wild animal herds as well as from stables with farm animals.

Before being utilized as a fuel, fresh dung must be dried. It's either left alone or shaped into spherical dung balls, flat dung cakes, or attached to a stick. Dung is blended with other types of fuel, like coal dust or farm leftovers, in some places to improve the burning performance and increase the energy density. Nevertheless, due to cultural beliefs, using of dung, particularly the drying of dung, may not be culturally acceptable in some countries.

Dung has a lesser heating value than wood because the organic matter concentration varies from 50-75% depending on the moisture content. The heating value of dung varies greatly depending on the kind of dung. According to Lizama et al., (2017), cow dung has values ranging from 10,000 kJ/kg to 18,000 kJ/kg. For this sort of gasoline, however, there is no consistent and thorough data available. Dung that has been sun dried has a low carbon concentration (approximately 25%). Dried wood, on the other hand, has a carbon level of around 50%, whereas coal has a carbon content of 70-90% (Verma et al., 2017). As a result, after a dung-fire, a large amount of ash remains in the stove.

Due to the fact that in some areas, burning dung is sometimes the only accessible energy source for homes, this method should be avoided whenever alternative acceptable solutions are accessible and appropriate, for the following reasons:

- Dung is a waste product of the digestive process, not an agricultural residues product, and has a great value as fertilizer.

- The fertility of the soil will be compromised if dung is widely utilized as a fuel.
- If long-term soil damage is to be averted, this loss in soil fertility must be supplemented by chemical fertilizer, charcoal, or alternative methods.
- When compared to wood, dung produces considerably more dioxins and chlorophenols, both are harmful to human health.

From an energy standpoint, methanization of dung in a biogas digester is a superior option, because when converted to biogas, cow dung comprises 50% methane and 30% carbon dioxide by mass (Dalkılıç & Dalkilic, 2021). Biogas generation at the home level, on the other hand, is far more complicated, since it entails geographical feasibility, financing costs, and water availability.

Firewood

The capacity to manage fire and use it to cook meals is a defining attribute of humanity. Firewood (Amoah et al., 2015), in the shape of logs and tree branches, is the earliest type of cooking fuel. The Food and Agriculture Organization of the United Nations (FAO) defines firewood (also known as fuelwood) as "wood in the rough (from tree trunks and branches) intended for use as a fuel for purposes such as cooking, heating, or power generation." (Amoah et al., 2015). Because softwoods have a lower energy (carbon) capacity per volume, they burn faster and produce less heat than hardwoods. Nevertheless, every hardwood and softwood have comparable heat capacity per weight; the energy value of a fuel is mostly determined by its moisture level. The less energy it takes to evaporate water from dry firewood, the more energy is generated for heating or cooking.

Charcoal

Carbonisation is a practice in which complex organic materials, like wood or other biomass, are decomposed into carbon and other chemical compounds by a gradual heating process. Charcoal is a solid fuel which is used for heating and cooking. Qu et al. (2016) opined that in general, the debate over charcoal focuses on the solid fuel used in underdeveloped economies rather than the material utilized in a wealthy country's barbecue.

Although the usage of charcoal can be harmful to the environment and health of its users, it is a superior cooking fuel than wood in most cases. Compared to wood stoves, charcoal stoves burn more efficiently and cleanly. This is a welcome development, but accessibility to better fuels would be much preferred. Nonetheless, charcoal manufacturing is significant since it provides a source of income for those who may be unable to find work elsewhere (Tukker et al., 2020). In many impoverished communities, charcoal is the primary source of energy. Because these families do not have a lot of money, charcoal is generally one of the most expensive items in their budget.

Note that charcoal is not the same as the briquettes often used on grills. Compared to lump charcoal or charcoal briquettes, traditional charcoal has a lesser purity. Traditional charcoal has more ashes than briquettes and contains mineral sand and clay that is taken up by the wood and its bark. Traditional charcoal can be purified by separating the ash using a sieve, leaving largely excellent charcoal pieces. The material is milled after the sifting process and then made into briquettes. The milled charcoal is combined with a binder and compressed into briquettes (Anggraeni et al., 2021).

Modern Cooking Fuel Choices

Kerosene

Kerosene, commonly known as paraffin, is a clear liquid fossil fuel produced by the refining of crude oil. Kerosene is very flammable and has been used for illumination all throughout the world; however, as industrialized countries became more electrified, kerosene became obsolete. Kerosene is still commonly used for lighting in underdeveloped nations, as well as for cooking and heating to a lesser level. More than 500 million households are expected to still use kerosene or other liquid fuels for lighting, resulting in a yearly consumption of 7.6 billion litres (Maiyoh et al., 2015)

Kerosene possesses a flash point of 37-65°C, an auto-ignition temperature of 220 degrees Celsius, and a huge energy density of roughly 43 MJ/kg (Raj et al., 2020). Kerosene is a combination of hydrocarbons chemically. The chemical make-up varies based on the source, but it typically comprises of roughly ten distinct hydrocarbons, each with 10-16 carbon atoms per molecule (Kuppusamy et al., 2019). The contaminant level of kerosene, particularly sulphur and aromatics, which limit combustion productivity and enhance toxic emissions during burning, determines the quality of the fuel.

In many underdeveloped nations, kerosene cooking is common, particularly in urban houses where biomass must be imported and power and LPG are costly or dependable (Thoday et al., 2018). Kerosene is normally delivered in large quantity, with rural regions buying it by the litre or bottle. According to research, there are just a few comprehensive studies that look at the amount of kerosene used for cooking and lighting. Osendarp et al., (2016) studied surveys, reports, and local communications from 23 countries, assuming a monthly intake of 1-10 litres per household. Cooking with kerosene is done with compact kerosene stoves, such as the Primus stoves, which were introduced in 1892, or the wick-stove.

Cooking Gas

Natural gas production and crude oil refining produce liquefied petroleum gas (LPG). LPG is a combination of hydrocarbon gases, with butane and propane being the most prevalent (Pasban et al., 2017). LPG is a colourless, odourless, non-toxic gas at room temperature. It changes into a liquid state at low pressure or at colder temperatures. This technique reduces the volume of the gaseous aggregate state to 1/250 of its original size, making it easier to store and transport LPG in cylinders. A LPG cylinder is only 80% filled with liquid for safety precaution, with the remaining 20% containing gaseous LPG (Tschirschwitz et al., 2018). A basic LPG cooking system consists of an LPG-filled steel cylinder, a temperature regulator, a tube which connects the cylinder to the pressure regulator and the burner, and lastly the burner itself.

The usable energy value of 1 kilogram of LPG is 20.7 MJ/kg. Air-dried firewood has an energy level of roughly 16 MJ/kg, while charcoal has a value of 27-33 MJ/kg. To supply an equal amount of useable cooking energy as 1 kilogram of LPG, between 7.3-29.7kg of wood fuel would be required, based on the kind of wood fuel, charcoal generation, and cook stove (Suresh et al., 2016). Because LPG is heavier than air (e.g., propane is 1.5 times heavier than air), it can collect above ground. This might result in LPG 'lakes,' which could produce explosions. To aid identify leaks and so minimise the extent of explosion, an offensive smelling odorant is included.

If the proportion of LPG in the air is between 2-10%, a combination of air and LPG can be ignited. The temperature of ignition is above 380°C. LPG has a maximum flame temperature of roughly 2,000°C. For many homes that desire to utilize LPG, the cost of the fuel remains a significant obstacle. Evidence demonstrates that subsidies benefited richer urban residents more than low-income users since the former can afford expensive initial expenditures, such as purchasing the cylinder and the LPG burner (Haque et al., 2021). In most nations, LPG is only available in metropolitan areas, and LPG supply problems are common in rural regions. Increased LPG use is also attributable to the minimal cost of fuel wood and a lack of understanding. Nonetheless, in areas where biomass is scarce, LPG might provide a major boost to biomass resources.

One of the key reasons for the increased usage of LPG across the world is its flexibility. LPG warms swiftly and efficiently, outperforming even the most advanced biomass stoves. LPG burners may also be adjusted more precisely to meet the needs of the user, saving time in the kitchen when cooking and cleaning. LPG may also be transported, stored, and utilized in almost any location.

Electricity

The suggestion by Union minister, Piyush Goyal to use electricity for cooking is quite good. This switch from LPG and piped gas to electricity for cooking will cut greenhouse gas emissions, relieve fiscal strain, and remove a part of the nation's hydrocarbon import expense, enhancing the country's balance of payment. Indoor air pollution is more likely to be reduced with electricity than with natural gas or LPG. Filling cylinders with cooking gas and transporting them across land is an energy and emission-intensive process. Because power lines already reach every town, the extra cost of delivering energy when electricity replaces cooking gas would be low. Use of renewable energy sources. One issue, according to Goyal, is finding technology that meets the needs of the Indian kitchen. Creating a technology that is superior to old-style hotplates and better than induction cooking would give a significant boost. This, however, would not be sufficient. According to studies, price has been a major stumbling block in the transition from traditional biomass to LPG for cooking. The biomass is harvested rather than purchased. The labour involved, which is mostly performed by women and children, is not compensated. As a result, the cooking fuel is effectively free. The LPG cylinder cannot compete even with incentives. As a result, demonstrating economic benefit for the switch to electricity is crucial. Utilities must also strengthen their billing and collection capabilities. The switch to electricity would be far more crippling if this did not happen. The use of distributed generation and net metering might be beneficial. Devolving a portion of the federal government's macro-savings to the states would be another option.

Solar

A solar cooker heat, cooks, bakes, or pasteurizes food or drink using the energy of direct sunshine. Solar cooking is a not a stand-alone technology since it only works when it is sunny. Solar energy may be an excellent addition to a household's energy mix, complementing existing combustion-based stoves that can provide heat on demand using other fuels. The extent to which solar energy may replace other fuels is determined on local cuisine and cooking practices. It is also highly reliant on local climate circumstances, which can drastically change over the course of a day or a year.

Cooking Fuel and Household Health

Cooking fuel is one of the environmental elements influenced by the household's socioeconomic status (Pongou et al., 2006). According to the World Health Organisation (WHO, 2002), the position of the kitchen in the home, for example, might cause indoor pollution, contaminating the air young children breathe. In certain cases, households may utilize two or three forms of cooking fuel, each with varied levels of danger due to the other's inaccessibility or price. In underdeveloped nations, indoor air pollution (IAP) from solid fuels (wood, charcoal, animal dung, coal, and agricultural waste) used for cooking and house heating is still a serious environmental and public health concern. Approximately 4.3 million individuals have died worldwide because of IAP-related disorders, including 534,000 children under the age of five. Most fatalities take place in low- and middle-income nations, such as Nigeria. Children under the age of five are one of the most vulnerable populations to suffer poor health because of solid fuel consumption, as they are present with their moms when they cook (Hardcastle et al., 2016).

The literature reveals that solid fuels are a common source of cooking energy in developing countries. Many people in underdeveloped nations rely on traditional cooking techniques such as unpressurised stoves and open fires due to the absence of advanced kitchen appliances, which results in ineffective and insufficient solid fuel combustion (Rehfuess et al., 2017). Furthermore, solid fuel has a poorer burning rate than clean fuel (Troncoso & da Silva, 2017). Several indoor air pollutants, such as black carbon, carbon monoxide, heavy metals, nitrous oxide, particulate matter, polycyclic aromatic hydrocarbons, sulphur dioxide, and volatile organic compounds, rise dramatically as solid fuel is transformed into partial combustion products (Streibel et al., 2015).

TABLE 1. SOLID FUEL AND ITS POST-COMBUSTION AIR POLLUTANTS, TOXICITY MECHANISMS, AND HEALTH IMPACTS

Solid Fuel	Air Pollutants Toxicity Mechanisms	Health Impacts
$^{PM}2.5,^{PM}10$	Systemic oxidative stress and inflammation	Asthma, lung cancer, chronic obstructive pulmonary disease, cough, aggravation of pre-existing symptoms
PHAs	Carcinogenic	Lung cancer, mouth cancer, naso-pharynx, and larynx cancer
Biomass and C0 coal	Carboxy-haemoglobin production, reduced delivery	Chronic obstructive pulmonary disease, oxygen exacerbation, low birth weight, perinatal death
NO_2	Increased reactivity and susceptibility to infection	Bronchial chronic obstructive pulmonary disease, lung exacerbation, low birth weight, perinatal death
SO_2	Increased bronchial reactivity	Wheezing, asthma exacerbation, cardiovascular disease
Smoke condensate	Absorption into lens and oxidative change	Cataract, impaired vision, conjunctiva disorders

Source: Granger (2017).

These air contaminants have all been proven to be hazardous to human health and to cause illness (Jiang et al., 2015). The majority of the world's population spends 80–90% of their time inside (WHO, 2017), where space is limited, and air movement is low. As a result, several researchers have calculated the levels of indoor air pollution generated by the burning of various solid fuels, such as coal (Balmes, 2019) and traditional biomass energy (Tun et al., 2019). For example, Du et al. (2018) did a meta-analysis of 92 papers in China on indoor air pollution and discovered that outdoor, bedroom, and kitchen concentrations for different air pollutants exhibited a significant increasing trend. The proportions of these contaminants are two to five times greater indoors than they are outside (Leung, 2015). Furthermore, indoor air pollutants and toxicity processes are frequently different depending on the solid fuel and combustion procedures used (Bruce et al., 2015). Table 1 provides a comprehensive overview of solid fuel combustion, accompanying air contaminants, and toxicity processes.

The dangers of solid fuel burning and indoor air pollution on occupants' health must not be overlooked. Women and the elderly are often the primary cooks in the home, and children frequently join their moms or the elderly (Balmes, 2019; Agrawal & Yamamoto, 2015). Air pollution from solid fuel burning, when compared to clean energy, tends to increase the risk of early death and a variety of diseases, as well as ocular diseases (Puzzolo & Pope, 2017), respiratory diseases, lung cancer, chronic obstructive pulmonary disease, immune system hypo function (Young et al., 2016), lung cancer (Zhai et al., 2018), hypertension and cardiovascular disease (Kjeldsen, 2018), and neonatal death and low birth weight (Gonzaga et al., 2015). When people switch to solid fuel for cooking, they generally have a negative perception of their health (Kar & Zerriffi, 2018). Table 1 provides a detailed explanation of solid fuel combustion and its health consequences.

RESEARCH METHODS

The research design adopted for this study is the survey design. The survey design is appropriate for the collection of information from a cross-section of the population of interest. In the survey design, appropriate instrument is designed for the purpose of collecting data from a cross-section of the population of interest. Sekaran and Bougie (2016) identified three unique characteristics of survey design. First, survey research design is used to quantitatively describe specific aspects of a given population. Second, research design determines the research methods used, and thirdly, research design is crucial for the kind of analyses performed. Finally, survey research design uses a selected portion of the population from which the findings can later be generalized back to the population. Given the nature of this study, the survey research design is appropriate for the study.

This study's population covers all permanently residing persons within Ibadan. The choice of population is informed by the main objective of this study which is to conduct an analysis of the effect of cooking fuel choice on respiratory health in Ibadan, Oyo State. Oyo State is located the Southwest geographical zone in Nigeria and derives its name from the ancient Oyo Empire was founded in 1976 from the former Western Region. Oyo State also has a total land area of 28,454km^2 and its population from the 2006 census is 5,580,094. Ibadan, as the capital city of Oyo State boasts a population 5,175,223 residents according to the last census figures.

To calculate sample size, the study relied on the Yemane formula since the population of the study (i.e., Ibadan residents) is known. In particular, the study relies on values published National population census of 2006 which puts Ibadan population at 5,175,223. The Yemane formula (1) is specifically presented as follows:

$$n = N/(1+N(e^2)) \qquad (1)$$

Such that *n* is the sample size, *N* represents population size, and *e* is the margin of error. Assuming a 5% margin of error, the sample size of the present study in which the population size of Ibadan residents is 5,175,223, is given as follows using the Yemane formula:

$$n = 5175223/(1+5175223(0.05^2))$$

$$n = 400$$

Hence, the sample size of the study comes to 400 respondents.

ANALYSIS AND DISCUSSION

Pattern of Household Respiratory Health by Household Characteristics

Questions relating to common respiratory health challenges were asked the respondents as part of the survey process and their responses have been tabulated in Table 2. Surprisingly, the incidence of respiratory health seems substantial among the sampled households. For instance, we see that as much as 33.3% of the sampled households had experienced coughing with some sneezing within the past three months prior to the survey. Likewise, those who had witnessed coughing accompanied by with breathing difficulties are 30.19% of the sampled households. A similar pattern can be observed in terms of coughing with catarrh (32.97% of households), breathing difficulties at nigh (30.17%), and coughing experiences lasting at least 3 weeks (31.25%). When viewed collectively, we see that only 182 households, amounting to 39.22% of the sampled households had not experienced any of the respiratory challenges listed.

TABLE 1. SAMPLE DISTRIBUTION BY HOUSEHOLD RESPIRATORY HEALTH

Variable	Obs.	Percent
Coughing with some sneezing		
No	310	66.81
Yes	154	33.19
Coughing with breathing difficulty		
No	323	69.61
Yes	141	30.39
Cough with catarrh		
No	311	67.03
Yes	153	32.97
Breathing difficulty at night		
No	324	69.83
Yes	140	30.17
Coughing incidence lasting 3 weeks or more		
No	319	68.75
Yes	145	31.25
None of the above		
No	282	60.78
Yes	182	39.22

Source: Author's calculations from survey data

To examine the pattern of household respiratory health by household characteristics, a dummy variable is generated from the responses provided on respiratory health that assumes the value of 1 (labelled "Yes") if the household experienced any of the respiratory health issues in Table 2 and 0 (labelled "No") if it experienced none. This variable is then cross-tabulated with the household characteristics with a chi-square test applied to the cross-tabulation. Table 3 shows the pattern of respiratory health by sex of household head. It seems that a greater proportion of male-headed households had experienced respiratory health issues (65.3%) whereas, more female-headed households had not experienced respiratory health issues (56.12%).

TABLE 2. PATTERN OF RESPIRATORY HEALTH BY SEX OF HEAD

Sex of head	Households experienced respiratory Issues		
	Yes	No	Total
Male	239	127	366
	65.3	34.7	100
Female	43	55	98
	43.88	56.12	100
Total	282	182	464
	60.78	39.22	100

Note: First row has *frequencies* and second row has *row percentages*
Chi^2: 14.88 (p. = 0.00)

Source: Author's calculations from survey data

Looking at the tabulation of respiratory health issues with ethnic origin of household head (Table 4), it seems to be the case that households that have experienced one form of respiratory health issue or the other are more than those that have not for all the categories of ethnicity listed. However, the incidence of respiratory health seems to be highest among household that have Hausa heads (77.05%) compared to other households.

TABLE 3. PATTERN OF RESPIRATORY HEALTH BY ETHNIC ORIGIN OF HEAD

Ethnic origin of head	Households experienced respiratory Issues		
	Yes	No	Total
Hausa	47	14	61
	77.05	22.95	100
Igbo	70	52	122
	57.38	42.62	100
Yoruba	117	93	210
	55.71	44.29	100
Other	48	23	71
	67.61	32.39	100
Total	282	182	464
	60.78	39.22	100

Note: First row has *frequencies* and second row has *row percentages*
Chi^2: 11.01 (p. = 0.01)

Source: Author's calculations from survey data

In Table 5, the distribution of household respiratory health by religion of household head has been presented. A repeatedly higher proportion of the households have had experiences of respiratory health issues compared to not having experienced it in the past three months. Among the religion categories, there is a higher proportion of households that have experienced respiratory health issues (88.57%) compared to others. Households with Christian heads have the least proportion of respiratory issues (53.15%).

TABLE 4. PATTERN OF RESPIRATORY HEALTH BY RELIGION OF HEAD

Religion of head	Households experienced respiratory issues		
	Yes	No	Total
Christianity	135	119	254
	53.15	46.85	100
Islam	116	59	175
	66.29	33.71	100
Other	31	4	35
	88.57	11.43	100
Total	282	182	464
	60.78	39.22	100

Note: First row has *frequencies* and second row has *row percentages*
Chi^2: 19.77 (p. = 0.00)

Source: Author's calculations from survey data

The pattern of respiratory health of the households by marital status of the household head is reported in Table 6. It appears that again, the proportion of households that have witnessed respiratory health issues are consistently higher for all the categories of marital status listed. Households with widowed heads are associated with the highest incidence of respiratory health issues (68.57%) whereas, those in the divorced/separated category are associated with the least incidence of respiratory health issues (57.5%).

TABLE 5. PATTERN OF RESPIRATORY HEALTH BY MARITAL STATUS OF HEAD

Marital status of head	Households experienced respiratory issues		
	Yes	No	Total
Never married	19	10	29
	65.52	34.48	100
Married monogamous	111	86	197
	56.35	43.65	100
Married polygamous	105	58	163
	64.42	35.58	100
Divorced/separated	23	17	40
	57.50	42.50	100
Widowed	24	11	35
	68.57	31.43	100
Total	282	182	464
	60.78	39.22	100

Note: First row has *frequencies* and second row has *row percentages*

Chi^2: 3.88 (p. = 0.42)

Source: Author's calculations from survey data

TABLE 6. PATTERN OF RESPIRATORY HEALTH BY EMPLOYMENT STATUS OF HEAD

Employment status of head	Households experienced respiratory issues		
	Yes	No	Total
Unemployed	9	6	15
	60	40	100
Self-employed	147	103	250
	58.8	41.2	100
Private sector	53	28	81
	65.43	34.57	100
Civil servant	73	45	118
	61.86	38.14	100
Total	282	182	464
	60.78	39.22	100

Note: First row has *frequencies* and second row has *row percentages*

Chi^2: 1.21 (p. = 0.75)

Source: Author's calculations from survey data

In terms of the pattern of respiratory health by household head's employment status (Table 7), there is also a higher proportion of households with respiratory health issues for all the employment status categories. There seems to be a greater incidence of respiratory health issues among households with heads in the private sector (65.43%) while the incidence is least among household heads who are self-employed (58.8%). Households with unemployed heads had a lesser incidence of respiratory issues (60%) than those who are civil servants (61.86%).

The incidence of respiratory issues by education of the household's head is reported in Table 8. There is a greater proportion of the incidence of respiratory issues for most of the categories of education. For example, households under the non-formal category had about 85.42% incidence of respiratory issues while those under the secondary category has a prevalence of 60.34%. Among households where the head has attained higher education, the incidence of respiratory health issues is 57.5%. Only among households where the head has attained only primary education did a higher proportion (62.5%) not experience respiratory issues.

TABLE 7. PATTERN OF RESPIRATORY HEALTH BY EDUCATION OF HEAD

Education of head	Households experienced respiratory issues		
	Yes	No	Total
Non-formal	41	7	48
	85.42	14.58	100
Primary	9	15	24
	37.5	62.5	100
Secondary	140	92	232
	60.34	39.66	100
Higher	92	68	160
	57.5	42.5	100
Total	282	182	464
	60.78	39.22	100

Note: First row has *frequencies* and second row has *row percentages*
Chi^2: 18.42 (p. = 0.00)

Source: Author's calculations from field survey

The incidence of respiratory health issues by household size is presented in Table 9. There is evidence that household of larger sizes have a higher incidence of respiratory health issue compared to households of smaller sizes. For example, households with less than 5 persons only experience 27.78% incidence of respiratory health issues. In the same vein, household that have 5-7 persons experienced 47.27% incidence of respiratory health. Comparing larger size households, we see exactly 77.14% incidence of respiratory health issues among households with 8-10 persons and those with more than 10 persons.

TABLE 8. PATTERN OF RESPIRATORY HEALTH BY HOUSEHOLD SIZE

Household size	Households experienced respiratory issues		
	Yes	No	Total
Less than 5	15	39	54
	27.78	72.22	100
5 to 7	78	87	165
	47.27	52.73	100
8 to 10	54	16	70
	77.14	22.86	100
More than 10	135	40	175
	77.14	22.86	100
Total	282	182	464
	60.78	39.22	100

Note: First row has *frequencies* and second row has *row percentages*
Chi²: 64.82 (p. = 0.00)

Source: Author's calculations from survey data

Pattern of Household Respiratory Health by Cooking Fuel Use

To examine the pattern of household respiratory health by cooking fuel use, a similar strategy was used as previously where the respiratory health variable is cross tabulated with the cooking fuel variable and a chi-square test performed to determine significance of variation.

TABLE 9. PATTERN OF RESPIRATORY HEALTH BY COOKING FUEL TYPE

Type of cooking fuel used	Households experienced respiratory issues		
	No	Yes	Total
Firewood	10	56	66
	15.15	84.85	100
Charcoal	17	53	70
	24.29	75.71	100
Kerosene	12	30	42
	28.57	71.43	100
Gas	143	143	286
	50.00	50.00	100
Total	182	282	464
	39.22	60.78	100

Note: First row has *frequencies* and second row has *row percentages*
Chi²: 35.53 (p. = 0.00)

Source: Author's calculations from survey data

Table 10 starts with the pattern of respiratory health incidence by cooking fuel type used by the household. The pattern that emerges confirms that households that use dirtier fuels are associated with a higher incidence of respiratory health issues compared to those that use cleaner fuels. In fact, the cleaner the fuel type, the lesser the incidence of respiratory health issues for households. Among households that use firewood for example, there is an 84.85% incidence compared to households that use charcoal with around 75.71% incidence. The incidence is even less when one considers households that use kerosene (71.43%) and least among households that use gas (50%). This could be an early indication of an adverse effect of dirty cooking fuel on respiratory health.

TABLE 10. PATTERN OF RESPIRATORY HEALTH BY FREQUENCY OF FUEL PURCHASE

Frequency of cooking fuel purchase	Households experienced respiratory issues		
	No	Yes	Total
Once a while	14	10	24
	58.33	41.67	100
Monthly	56	61	117
	47.86	52.14	100
Twice monthly	79	107	186
	42.47	57.53	100
Weekly	33	104	137
	24.09	75.91	100
Total	182	282	464
	39.22	60.78	100

Note: First row has *frequencies* and second row has *row percentages*
Chi^2: 21.33 (p. = 0.00)
Source: Author's calculations from survey data

The pattern of respiratory health by frequency of fuel purchase is presented in Table 11. As expected, there is evidence that a higher frequency of fuel choice is associated with a higher incidence of respiratory health issues. Households where the cooking fuel of choice is purchased once a while have an incidence rate of 41.67% only whereas, among households that purchase monthly, the incidence of respiratory health issues is higher (52.14%). In the same way, among households that purchase their cooking fuel twice monthly, the incidence of respiratory health issues is lower (57.53%) than among households that purchase weekly (75.91%).

The pattern of respiratory health by cooking location is next presented in Table 12. As per cooking outside, it appears that the incidence of respiratory health issues is higher among households that cook outside their main dwelling than among those that cook inside their main dwelling. This is probably because persons that cook outside mostly do so with less clean fuels like firewood and charcoal. The incidence is highest among households that cook in the open space (80.73%) and least among those that have a kitchen in their main dwelling (37.95%). Such households probably cook with cleaner fuels in their kitchens with good ventilation. On the other hand, households with a kitchen in their sitting room have more than 50% incidence of respiratory health issues whereas, those with kitchens in the same room as their sleeping room have a high incidence rate (80%).

TABLE 11. PATTERN OF RESPIRATORY HEALTH BY COOKING LOCATION

Usual Cooking Location	Households experienced respiratory issues		
	No	Yes	Total
Kitchen outside main house	13	35	48
	27.08	72.92	100
Open space outside	37	155	192
	19.27	80.73	100
Separate kitchen within main house	121	74	195
	62.05	37.95	100
Kitchen is inside sitting room	10	14	24
	41.67	58.33	100
Kitchen inside the same sleeping room	1	4	5
	20.00	80.00	100
Total	182	282	464
	39.22	60.78	100

Note: First row has *frequencies* and second row has *row percentages*
Chi^2: 78.49 (p. = 0.00)

Source: Author's calculations from survey data

DISCUSSION AND RECOMMENDATION

The findings of this study have shown that the incidence of respiratory health issues is greater in households that are female headed than in those that are male headed. One possible cause of this is that female headed households tend to be less socioeconomically endowed relative to male-headed households. Given the greater opportunities for employment for men whether in the formal or informal sector, households that are headed by a female would, on average have less socioeconomic endowment which means that they might be more associated with unclean fuel use and are thus, more likely to experience respiratory health issues as a result. The findings also revealed that the incidence of respiratory health issues would likely decrease with the education level of Ibadan household heads. It was shown that in fact, households headed by persons with primary education experience the highest incidence of respiratory health challenges (62.5%). This result has implication for socioeconomic endowment that is likely associated with having higher education. As stated by some researchers (Adamu et al., 2020; Hiemstra-van der Horst & Hovorka, 2008; Yadav et al., 2021), better socioeconomic status leads to the use of cleaner cooking fuels and possibly, less experience of the incidence of respiratory health challenges.

Another interesting finding relates to how respiratory health incidence varies by household size. The findings showed clearly that the incidence of respiratory health challenges tends to increase as household size increases. A useful way of interpreting or viewing this incidence is to examine the results vis-à-vis socioeconomic status. It is logical to expect that in larger households, limited resources are shared by a larger number of persons, leading to smaller and smaller per capita consumption on average. This means that socioeconomic constraints would likely rise on average, the larger the household size. Intuitively, it means that larger households are unable, at least on average, to start using cleaner cooking fuel and thus, decrease their dependence on less clean cooking fuels. The implication is that larger households would likely be associated with a higher incidence of respiratory health challenges. To buttress these arguments, the incidence of respiratory health issues was found to be decreasing with cleaner cooking fuel use (i.e., the cleaner the cooking fuel, the lesser the incidence of respiratory health issues as seen in Table 10). Likewise, the incidence of respiratory health issues is found to increase as the frequency of purchasing the cooking fuel of choice, which is used to indicate dependence on the cooking fuel, increases. These results provided evidence that cooking fuel choice might have a substantial impact on household respiratory health in Ibadan.

The findings relating to each cooking fuel type provide partial support for the previous findings. The risk of respiratory health declines with the cooking fuel "cleanliness" up to the kerosene category at which it is incidentally significant. The findings demonstrate that households that rely on kerosene have around 28% less probability of reporting a respiratory health issue relative to those that rely on firewood. Firewood thus seems to be a high-risk fuel in terms of respiratory health challenges among Ibadan households, judging from the high incidence of respiratory health challenges among firewood users found in Table 10.

As per the frequency of cooking fuel purchase which proxies the dependence on the cooking fuel of choice, it is hardly surprising to see that the risk of respiratory health challenges rises with these frequencies. A greater dependence on unclean cooking fuel would, all else equal increase the exposure to health risks, and thus, increase the incidence of respiratory challenges. This is a clear indication of how constraints limit the ability to enjoy cooking cleaner fuels and experience less respiratory health challenges.

The findings of this study have implications for policy formulation which are worth mentioning. For instance, there is need for sensitizing households in Ibadan and indeed, Nigeria on the respiratory health implications of cooking with unclean fuels like firewood and charcoal. Government, non-governmental organisations, and relevant stakeholders can facilitate advertisements, campaigns, and awareness programmes about the health hazards associated with unclean cooking fuels especially in the rural areas where there is more likely to be a greater reliance on such cooking fuels.

Given socioeconomic constraints, government can make effort to increase accessibility to cleaner cooking fuel for the purpose of decreasing the incidence of respiratory health challenges among Ibadan households and in Nigeria as a whole. One approach is to subsidize the capital cost of cleaner fuel use such as gas cylinders, kerosene stoves, electric cookers and so on. This could go a long way to decrease dependence on unclean cooking fuel and therefore, decrease the incidence of respiratory health challenges.

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