DOMESTIC ENERGY USE AND THE PREVALENCE OF RESPIRATORY INFECTIONS IN ILORIN, NIGERIA

U.A. Raheem¹, R.A. Shehu², A.M. Tunde¹ I.O. Orire ¹
¹Department of Geography and Environmental Management, Faculty of Business and Social Sciences, University of Ilorin, P.M.B. 1515, Ilorin, Nigeria
²Department of Human Kinetics and Health Education, Faculty of Education, University of Ilorin, P.M.B. 1515, Ilorin, Nigeria

ABSTRACT
Given their consequences on human health, indoor air pollution generated through domestic energy consumption is more important than outdoor pollution in the third world. The understanding however, of the intricate link between energy and health lags behind that of the linkages between water or waste management and health. The consequences of energy consumption have not been reflected in health care priorities in most countries. Apart from studies that examined the relationship between poverty and energy, studies are also scanty in the identification of both area and structural characteristics of urban population in relation to energy use. This study identifies the nature, types and sources of energy used by household; so as to obtain a gradient of the characteristics of energy consumption in cities of developing countries. The sources of data were primary and secondary. Multiple regression analysis was used to determine the relative contributions of household characteristics to the pattern of energy use. The findings revealed that occupation, household size, gender and education of household heads were significantly related to the use of unclean energy in the community. Incidence of cough either in the morning or evening, chest illness and watery or blood shot eyes were due to the combined effects of smoke inhaled and these are common symptoms of persons who use unclean energy. The authors recommend among others that households be encouraged to adopt measures that will reduce exposure to smoke as a means of adaptation.

INTRODUCTION
The energy sub-sector is a strategic component of an overall assessment of the functioning of the ecosystem. This functioning also possesses trans-boundary influences on the ability of ecosystems to provide support to the human community. The harvesting, processing, distribution and use of fuels and other sources of energy have been shown to have major implications for human health (Rosenzweig and Foster, 2003; Hosier and Kipondya, 1993). More than half of the inhabitants of the planet earth (over 3 billion people) still depend solely on solid biomass fuel for domestic energy consumption. These types of energy also occupy the lowest rung in the energy ladder due to their poor combustion and high concentration of toxic pollutants. High concentration of Particulate Matter (PM), Carbon monoxide (Co), Oxides of Nitrogen, Sulphur dioxides (SO₂) and volatile organic compounds are able to penetrate deep into the lungs and appear to have great potentials...
to damage health (Sarangupani and Wexler, 1999). Thus exposure to these elements have been shown to be associated with chronic obstructive pulmonary diseases, lung cancer, nasopharyngeal cancer, tuberculosis and also asymptomatic for some diseases of the eye in adults (Smith, 2000; Barnes et al., 2009).

Studies are however scanty in the exploration of the household socio-economic factors that may produce the observed pattern of energy use and the consequences for household health particularly in developing countries. In this study, it is hypothesized that although there is inherent multiple coincidence of causation, the effects of energy consumption could be isolated for households, and a magnitude of explanation may be ascribed to energy consumption in the overall pattern of disease occurrence in such household. Thus, the paper characterizes the household socio-economic factors that may be confounded with energy use in a third world city; and explore the effects of this for the occurrence of symptoms of respiratory infections in household members.

This study is justified on the basis of the fact that acute lower respiratory infections constitute a major cause of death accounting for a substantial global burden of disease in Africa. The most vulnerable groups are women who are normally responsible for food preparation and cooking as well as children under the age of 5 years and infants who are usually around their mothers when they cook. It must be noted that although majority of the vulnerable to this risk are rural dwellers where disposable income for energy is limited and access to clean energy is greatly constrained. This is increasingly becoming a problem of poor urban dwellers, a trend likely to increase with the urban transition (Schirinding et al., 2002). A study of the health consequences of exposure from biomass and other solid fuels in an African city could be justified from the perspective of three interrelated reasons: (i) there is uncertainty associated with the exact risk estimates, the health burden from unclean energy is unacceptably high. (ii) biomass and coal will continue to be used by a large number of households and may increase in the future (World Energy Council, 1993), and (iii) the burden of disease from biomass energy use is highly concentrated in poor societies and groups that are also unable to, on their own, respond adequately to the threat. Among all environmental risks to human health, Indoor Air Pollution (IAP) resulting from domestic energy use is well recognized as a traditional hazard which is also related to poverty. According to Bradley (1992), nutrition, water and sanitation, diarrhea diseases, children and the technical aspects of tropical diseases has been extensive in developing countries while the understanding of energy-health linkages was as advanced as it was for others; even when it is estimated that solid fuel used accounts for 4.7% of deaths in developing countries and 4.3% of disability adjusted life year (Listordi and Doumani, 2004). Solid fuel comes third after malnutrition (14.9%) of all deaths in developing countries (Smith and Mehtra, 2000). Another area of focus in public health investigations has been the risk from environmental hazards and energy in particular due to occupation, the elderly and the woman. In each case, each of these groups are said to suffer singly or jointly, the health impact of energy related to diseases and conditions of air pollution, injuries, stress and other conditions as well as vector related diseases. Issues on gender and energy have not received much priority research attention (Listordi and Doumani, 2004). This is because researchers have focused more on the developed countries whose major preoccupation is the pollution that is generated from industrial activities rather than the activities at the micro level like the household energy use in the developing countries. About 90% of the US $56 Billion invested in health research and development by the public and private health sectors goes into research on only 10% of the world’s population (Committee on Environmental Health, 1999).

This study will examine the relationship between domestic energy use and the prevalence of respiratory infections in Ilorin, the capital city of Kwara State, Nigeria.
MATERIALS AND METHODS
This study employs a structured questionnaire to elicit information from 500 households sampled from the twenty traditional wards. Twenty-five households were sampled using a stratified random sampling of houses from the geometric centre of each ward. From such centres, one out of every ten houses was sampled and only one household was sampled in case of multi-family dwellings. The heads of households were targeted for interview. The questions were drawn to reveal the socioeconomic circumstances of households as well as how this affects their choice of domestic energy consumption. The questionnaires also requested households to recollect common household illness and diseases including the first major steps taken when such illnesses occur. Both descriptive and inferential statistics were used to analyze the data. At this juncture there is the need to give a brief description of the study area.

The setting for this study is Ilorin metropolis, the capital city of Kwara State in Nigeria. The city is located on latitude 8° 32'N and long. 4° 35' E, marking simultaneously, the cultural and ecological divide between the south-western forest and the Northern grassland zone of the country. The vegetation is in most parts of guinea savanna interspersed by trees of different species. The climate is tropical wet and dry characterized by a distinct wet and dry seasons. The mean annual temperature is above 26°C with at least five hours of daily sunshine. The mean annual rainfall is about 125mm within the city.

It is possible to delimit, even if roughly, residential groupings determined by both housing density and their crowding index (Olorunfemi, 1981). The changing economic base of the city is also a general framework, which the growth of the city can be explained. Hence, its role as provincial headquarters since the colonial period, state capital since 1967, and the economic effects of oil boom era of 1970s brought with it physical development projects. These projects include the army barracks; Adewole Housing Estates, the International Airport, and the Niger River Development Authority among others are developments that attracted physical growth for the city in its different directions and at different times and rates. The physical growth generated through this momentum also translates into significant changes on the population of the city. The population of the city was 36,000 people in 1911; 208,000 in 1963 and 777,667 by the year 2006 (NPC, 2006). This shows a growth rate of 2.8 percent per annum. Although the population of the city might have changed significantly in size, the residential characteristics of its people have remained geographically stable. This determined often by the levels of income and ethnic affliction of the people. Hence the natives who possess their “family houses” in their interior area inhabit the inner city predominantly. The dwelling units here are multi-family houses containing several rooms in traditionally designed edifices. It is important to note that the population here possesses higher tendencies for residential mobility as levels income or education improves. Outside the inner city is the Central Business District (CBD), which is interspersed by native houses. Hence, commercial nerve centres developed outside the city centre comprise of early migrants and early movers from the city centre. The third is the urban frontier comprised of the development efforts like the Adewole, Kulende and Oloje Low Cost Housing Estates. Finally, there is the suburbia and the urban fringe, which includes old villages that have benefited from “urban invasion”. The city as described above is divided into twenty traditional wards for administrative purposes and adopted in this study for analytical convenience.

The Survey and the Variables
The responses from the survey were analyzed based on the twenty wards. In all, the responses were grouped into three broad categories containing separate variables. These include household and household head characteristics, residential quality and pollution related health problems. The variable under each of these groups are as listed and defined below.
Households and Household Heads Characteristics

Gender of Household heads: The study was interested only in the number of households headed by female.

Education of Household head: Calculated as the number of household heads without basic qualification for paid employment

Average Household size per ward: This was calculated as the total number of members in all sampled households in each ward divided by the total sampled households (25) for the ward.

Occupation of Household Heads: Calculated as the proportion of household heads that were engaged in informal occupation per ward.

Residential Quality

Number of households using unclean energy for domestic cooking: This is defined as the total number of households using biomass fuel for cooking domestic food.

Number of houses without separate kitchen: Proportion of households without cooking places located within the house; or houses with one kitchen shared by several households.

Number of households cooking indoor including total number of households cooking in their sleeping rooms or at a common passage in multi-family houses. This is to determine the number of households whose cooking habit increases the tendency for indoor air pollution.

Technology for cooking household food is taken here to include smoke generating instruments like kerosene stove, fireplace either mud or iron fabricated that accept firewood, saw dust, grass and animal dung for making fire and coal pot using charcoal. The basic feature of these instruments is their incomplete combustion.

Pollution Related Health Problems

The study requested households to identify health characteristics of members that may be symptomatic of respiratory infections. Seven of such household health conditions were identified. These are the total number of household member per ward that

- Cough first thing in the morning (CUFMOR)
- Cough during the day or night (CUFEVEN)
- Bring out spittle when coughing (SPITTLCUF)
- Cough up to at least three months in one year (CUFTHREE)
- Bring out blood tinted spittle (BLODSPIT)
- Report chest illness in one year (CHESTILL)
- Possessing watery or blood shot eyes. (WATEREYE)

Cough is generally recognized as suggestive of symptoms of upper respiratory tract infection. These symptoms may also lead to or be consequence of nasal stuffiness and dripping, head congestion, sore throat or slight eye redness. The notations in parentheses are relevant to model 2 below. The presence of these indicators in different combinations is suggestive of the presence of respiratory tract infections when other factors act in coincidence to determine the magnitude and intensity. Multiple regression models were used to determine the relationship between household characteristics and the use of unclean energy and the consequences of this on the reported proxies of respiratory tract infections.

The Models

Model 1: The first model examines the correlates of energy use among households in Ilorin metropolis using household characteristics. The model is expressed as

\[ EU = f(HHS) \]  \hspace{1cm} (1)

Where

- \( EU \) = Energy Use
- \( HHS \) = Household characteristics identified above

Thus,

\[ HHS = f(OccHH, HHsize, EDHH, FHH) \]  \hspace{1cm} (2)

Substituting equation (2) into (1)

\[ EU = f(OccHH, HHsize, EDHH, FHH) \]  \hspace{1cm} (3)

Where

- \( OccHH \) = occupation of Household Heads
- \( HHsize \) = Household Size
- \( EDHH \) = Level of Education of household Head
- \( FHH \) = Proportion of Households Headed by
Based on Eq. 3 above, a multiple linear relationship was established in the form

\[ EU = b_0 + b_1 \text{OccHH} + b_2 \text{HHsize} + b_3 \text{EDHH} + b_4 \text{FHH} + e \]  

(4)

Where

\[ b_0 = \text{the intercept} \]
\[ b_0 - b_4 = \text{estimation parameters defined earlier} \]
\[ e = \text{Residual error term.} \]

**Model 2:** The second model examines the relationship between the use of unclean energy and the reported pollution related health problems.

The model is of the form

\[ EU = f(\text{RTI}) \]  

(5)

Where

\[ \text{RTI} = \text{Respiratory Tract Infections proxied by seven symptomatic variables as indicated above; with} \]
\[ f(\text{CUFMOR, CUFEVEN, SPITTLCFU, CUFTHREE, BLODSPIT, CHESTILL, WATEREYE}) \]  

(6)

Thus,

\[ f(\text{CUFMOR, CUFEVEN, SPITTLCFU, CUFTHREE, BLODSPIT, CHESTILL, WATEREYE}). \]  

(7)

The regression equation

\[ \alpha_0 + \alpha_1 \text{CUFMOR} + \alpha_2 \text{CUFEVEN} + \alpha_3 \text{SPITTLCFU} + \alpha_4 \text{CUFTHREE} + \alpha_5 \text{BLODSPIT} + \alpha_6 \text{CHESTILL} + \alpha_7 \text{WATEREYE} + e \]  

(8)

Where

\[ \alpha_1 = \text{intercept} \]
\[ \alpha_1 - \alpha_7 = \text{estimation parameters} \]
\[ e = \text{residual error term} \]

In the estimation of the models above, two evaluation criteria were used. These include the setting of a-priori expectations for the behaviour of each variable within the context of the independent variables. These expectations were based on the signs and magnitude of coefficients of the variables of interest. The second criterion is the use of statistical characteristics of the variables otherwise referred to as the first Order Least Square (OLS) test which consists of \( R^2 \), F-statistics and t-test. These parameters test the overall significance of the regression analysis and the significance of each independent variable. Thus, in the two models, the behaviour of the independent variable is such that \( B_i - \beta_j > 0 \) and \( \alpha_1 - \alpha_7 > 0 \). In other words, we expect positive values for our estimation parameters in both models.

**RESULTS**

The results of the multiple regression analyses from the two models is as shown in Table 1.

**Table 1: Multiple Regression Analysis of The Correlates and Health Consequences of Urban Energy use in Ilorin, Nigeria.**

<table>
<thead>
<tr>
<th>Explanatory Variables</th>
<th>Models 1 (t-values)</th>
<th>Models 2 (t-values)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>7.05 (1.45)</td>
<td></td>
</tr>
<tr>
<td>OccHH</td>
<td>0.52 (1.53)</td>
<td></td>
</tr>
<tr>
<td>HHsize EDHH</td>
<td>0.44 (0.88)</td>
<td></td>
</tr>
<tr>
<td>FHH</td>
<td>0.31 (1.08)</td>
<td>0.53 (0.89)</td>
</tr>
<tr>
<td>UFMOR</td>
<td>-0.61 (-1.90)</td>
<td>0.34 (0.70)</td>
</tr>
<tr>
<td>CUFEVENSPITC</td>
<td>-0.80 (-0.8)</td>
<td></td>
</tr>
<tr>
<td>UF</td>
<td>1.45 (1.46)</td>
<td></td>
</tr>
<tr>
<td>CUFTHREE</td>
<td>-0.11 (-0.12)</td>
<td></td>
</tr>
<tr>
<td>BLODSPIT</td>
<td>0.51 (0.89)</td>
<td></td>
</tr>
<tr>
<td>WATEREYE</td>
<td>0.33 (1.12)</td>
<td></td>
</tr>
<tr>
<td>( R^2 )</td>
<td>0.48</td>
<td>0.45</td>
</tr>
<tr>
<td>F</td>
<td>3.50</td>
<td>1.71</td>
</tr>
<tr>
<td>No. of cases</td>
<td>500</td>
<td>500</td>
</tr>
</tbody>
</table>
Correlates of Energy Use among Households in Ilorin

As shown in Table 1, the model gives an $R^2$ of 48%, which indicates that 48% variation in the dependent variable (energy use) is explained by selected explanatory variables while the remaining 52% may be explained by other variables not included in the model. At 5% level of significance, the F-statistics shows that the model is useful in determining if any significant relationship exists between use of energy and selected characteristics of heads of households; the $F_{cal}$ (3.50) > $F_{tab}$ (1.64). The coefficient and the associated t-value (in parentheses) of the components of the household characteristics used in the analysis indicate that occupation of household heads, household size and education of household heads fulfilled the a-priori expectations whereas gender of household heads is shown to possess no positive relationship with the use of unclean energy. This is suggesting that the belief that households that are headed by females are likely to use more of unclean energy is set aside by the result of this analysis. This may be related to the fact that female-headed households are usually smaller than those headed by males. The energy demand for domestic use by female headed households is usually low and hence heads may be able to afford cleaner energy carriers for cooking. This is corroborated by the finding in this study that household size possesses positive relationship (44%) with the use of unclean energy. Household heads occupation is also related to the level of education of household heads. The two also possesses positive relationship with the use of unclean energy. In essence, the tendency to engage in informal and non-urban occupation also means low income which precludes such households from purchasing cleaner energy carriers. The source indicated by households in the survey also shows that 39% of households obtained their unclean energy types from farms.

Health Consequences of Indoor Air Pollution

Model 2 shows that 45% of the prevalence of the selected proxies of respiratory tract infections were explained by the use of unclean energy. The F-statistics also shows that our model is useful in determining the relative contribution of energy use to the prevalence respiratory tract infection ($F_{cal}$ 1.89 > $F_{tab}$ 1.64 at 5%). Among the seven proxies of respiratory tract infections, two were shown to possess no positive relationship with unclean energy use. These are ‘bringing out of spittle’ when respondents cough otherwise known as productive cough; and respondents noticing bloodstains in their spittle. These two variables are both related to having productive cough that leads to spittle containing bloodstain. The remaining five variables also fulfilled our expected behaviour as they were shown to be related to use of unclean energy at varying magnitudes. It is important to note that the incidence of cough either in the morning or evening is related directly to use of unclean energy; importantly the findings include the fact that such cough is persistent and may last for up to three months or more. The results include chest illness and watery or blood shot eyes due to the combined effects of smoke inhaled and persistent cough. The implications of these findings are discussed in the next section of this paper.

DISCUSSION

This study examines the extent to which the type of energy used by households could be attributed to the socio-economic characteristics of the household heads. The study also examined the implications of this for household heads in Ilorin, Nigeria. The study implies that the household scale is important in the prevalence of respiratory tract infections in developing countries where biomass fuel is still the most dominant energy carrier. Research attention should therefore be focused on the exploration of the links between and among poverty, household characteristics, biomass fuel and environmental health risks. Aside this, we must also understand the socio-economic factors that drives behavioral change particularly among the poor and conservative urban dwellers. This change is determined in part by the knowledge of risk available to households about energy use and respiratory
tract infections. Currently, studies are scanty that explore the promotion of behavioral changes. To reverse this trend, there must be a shift in the ongoing policy and research paradigms in the third world. A policy change is required in the area of energy and IAP particularly in urban centres of Africa where population density and poverty are high and increasing. Thus, a great number of people are exposed simultaneously to the effects of unclean energy. There must be appropriate risk communication particularly to women and advice on how to protect their children from pollution generated by the activities of their own cooking. When people are aware of the risks involved in their activity, they are likely to make informed decisions and choices. The current state of such awareness is quite low in developing countries. In separate surveys, Parikh and Laxim (2000) in India; and Benneh et al. (1993) in Ghana reported that households ranked pollution from smoke in kitchens as fourth environmental concern, which goes to corroborate the current state of carefree on the part of the prime victims-women

CONCLUSION
It has been shown that structural characteristic of households are important determinants of unclean energy use. This energy carrier possesses far reaching implications for Indoor Air Pollution and human health in African cities. Public health would therefore benefit immensely from an adequate knowledge of the social and spatial characteristics of households since it is the micro-level energy use that is more important in indoor air pollution. Effort is therefore required in clearly obtaining an inventory of household cooking habits, the factors that determine these and their spatial variation within cities. This is with a view to targeting households as focal point for intervention programmes for clean energy. In this respect, an important factor is the prices and availability of other energy carriers. The prices of gas and kerosene have increased more than ten folds since 1999 in Nigeria with a corresponding increase in levels of poverty among people. These taken together, households are forced to adopt the unclean carriers of energy for cooking.

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REFERENCES


