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Correlates and Health Consequences of Indoor Air Pollution among Urban Households in Ilorin, Nigeria

[1]A. Raheem Usman and [2]Raheem A. Sheu
[1]Department of Geography, University of Ilorin, Ilorin, Nigeria
[2]Department of Human Kinetics and Health Education, University of Ilorin, 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 examine 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 households for domestic purposes in Ilorin, Nigeria. The specific tasks of the study include establishing a spatial pattern of the variation in the types and quantity of energy used by households so as to obtain a gradient of the characteristics of energy consumption in cities of developing countries. This is expected to lead to a corresponding variation in the health consequences resulting from the use of such energy types. These tasks will enhance a clearer understanding of the link between energy and city wide environmental health. Multiple Regression analysis and other relevant statistics would be used to determine the relative contributions of household characteristics to the pattern of energy use. The sources of data are primary and secondary.

Key words: IAP, household, third world cities, health problems, air pollution, Nigeria

INTRODUCTION

In modern times and societies, there is a complex relationship between the environment, broadly defined and human health. This relationship is also assuming transboundary dynamism when viewed against the backdrop of social, political and economic circumstances that affect both the environment and health simultaneously. Thus, the health and well being of humans cannot be rightly separated from the total environment. Indeed, the greatest challenge to human health today is a mirage of ecosystem related factors that span from the household scenario and dovetail in a complex interplay to a global dimension.

Each of these factors interacts to produce an impact on human health. It is still an enormous research challenge to identify the magnitude of individual influences on the general human health and wellbeing. This challenge is also the major reason for the contemplation of such perspectives as ecosystem approach to human health (ecohealth).

Threats to human health are constantly being generated from two categories of human environment interaction. Firstly, lack of development referring to man's inability to cope with natural resources or restricted access to environmental resources. Secondly, threats are also being produced from unsustainable development which leads to ecosystem degradation (World Resources Institute, 1998). In this category is the harvesting, processing, distribution and use of fuels and other sources of energy.

These activities have being shown to possess major environmental implications (Rosenzweig and Foster, 2003; Hosier and Kipondya, 1993). Studies are however, scanty in the exploration of the factors that may produce a typical urban energy use and the consequences this may possess for human health. This forms the basis of the present study.

While contending with inherent multiple coincidence the effects of energy consumption may produce for the households as well as the combination of the effects of other households energy consumption patterns, the study attempts to characterize the factors that may be confounded with a typical energy use scenario in a third world city and explore the pollution scenario produced from the variation in the type of energy used by urban households. The objectives of the study include:

Corresponding Author: A. Raheem Usman, Department of Geography, University of Ilorin, Ilorin, Nigeria

- To identify the type of energy used by sampled households in Ilorin city. In the city, energy types commonly used include gas, electricity, kerosene, firewood, charcoal, sawdust, grasses and animal dung. The interest in the study is to identify the households using clean energy types from those using energy types in the unclean category. Only households using gas and electricity to prepare domestic food are in the clean category while households using all other energy types mentioned before or related ones are classified as using unclean energy. These are so qualified because of the possibility of incomplete combustion from the unclean energy and their ability to produce dangerous gases that may be injurious to human health
- Identify the spatial patterns that this exhibits and examine the house household demographic and socio-economic factors that may influence the choice of energy used by households for domestic cooking, lighting, etc.
- Finally, the study attempts to establish relationship between the use of unclean energy category and some selected self reported pollution related health conditions in sampled households

Energy and human/ecosystem health: A framework and justification: The energy sub-sector is a strategic component of an over all assessment of the functioning of the ecosystem. This functioning also possesses a transboundary influences on the ability of ecosystems to provide support to the human community including shelter, food, clothing and capacity to assimilate and recycle waste, clean air as well as water. Through, the activities of man, more than half of the land surface have been modified and the effects of this modification accounts for >20% of the atmospheric carbon dioxide concentration. Humans have also utilized about 50% of the accessible surface fresh water and are responsible for about 60% of all nitrogen fixation.

The totality of the impacts of these modifications possesses great danger to the continued functioning of the natural life support systems and thus human health is put ‘on line’ each time the activities of humans threaten the health and sustainability of the ecosystem. Human activities generate and liberate a significant proportion of biologically active elements and compounds into the atmosphere, surface waters and soil at rates far beyond natural flows of these substances. Within this plethora of modifications, indoor air pollution from household activities is a major human activity that may (and do) produce negative consequences for human and ecosystem health. A critical study of this activity is therefore, necessary because it is perhaps the most important insult into the general ecosystem given its routine and accidental release of pollutants. Researches in the area of pollution and human health have emphasized the developed world perspective to pollution. This perspective is characterized by the exploration of the emissions into the earth’s surface of injurious substances from the activities of urbanization, transportation and industrialization.

In these parts of the world energy consumption transition has shifted from the concern for the influence of micro level consumption behavior such as household energy use and the question of clean or otherwise of energy at these levels. The emphasis in the developed world is for a more global concern for the impact of macro level energy use and its implication for outdoor air pollution. For this reason, the understanding of the linkages between energy and health lags behind that of the linkages between such other contexts as waste/water management and health (World Bank, 2000). Hence, health has not been systematically integrated into energy projects in most third world countries.

For instance, Nigeria contains about 13% of the Sub-Saharan African vehicles but has not included pollution reduction into its National Environmental Action Plan (NEAP), although it is discussing the use of unleaded fuel over the medium term (World Bank, 2000).

As humans burn solid fuels for warmth, security, cooking and domestic purposes, the epidemiology of respiratory infections which possesses a cluster around poorly ventilated homes of developing world has been shown to cause serious health problems leading to the death of up to 1.6 million people annually using the medium of indoor air pollution (WHO, 2002). Women and children are most affected because women do most of the cooking and inhale more smoke while children are always in-door with their mothers near the fireplace. Evidence is now overwhelming that carbon dioxide emission from the energy sector accounts for >50% of the human contribution to greenhouse effect. Despite this, the strategic and environmental consequences of the patterns of energy consumption were virtually neglected or spoken around for a long time.

Thus, overtime a series of conflicts have been generated between energy on one hand, human health and future of the planet on the other. Energy is now being acknowledged to be central to the generation and sustenance of these conflicts. The household scale is important because it is the oldest human energy technology and home cooking fire persists as the most prevalent fuel using technology in the world accounting for >50% of energy demand in countries with per capital incomes of >1000 US$ (Holdren and Smith, 2000). The highest energy demand is also at the household level for home cooking. The energy ladder is an appropriate framework for the understanding the spectrum of energy consumption and their relative contribution to pollution within the household. According to the ladder, poor households use more of the unclean energy types ranging from wood, dung, grass or crop residues and less of clean energy types like electricity and Liquefied Petroleum Gas (LPG).

There are different purposes for using energy in different households. The major activity requiring energy use includes cooking water heating, lighting and space heating.

It is important to note that different carriers of energy can be used for each of these activities. Firewood, charcoal, dung, crop residues, kerosene, electricity or LPG are some of the energy carriers that can be used for cooking while kerosene and electricity are used for lighting. These carriers form what is commonly referred to as energy ladder for the activity.

The rungs of the ladder are income sensitive because the choice of the energy adopter for an activity by a given household is a function of the percentage of the household income that can be expended on energy for that activity. Hence, each rung of an energy ladder represent only the dominant but not the sole energy used by households in the particular income group. The rung is not the sole energy type because given irregularities in supply or prices, households may adopt other fuels as backup in place of the proffered (Reddy and Reddy, 1994). For most households, it is the income and price of energy options that restrict the choice.

Wood, dung and other unclean biomass fuels occupy the lowest rung in the ladder for cooking while charcoal and coal as well as kerosene represents higher steps up the ladder; the highest rung is occupied by electricity and LPG.

It must be noted that along the energy ladder, just as energy options have different qualities, they also have different prices as well as emission characteristics. Hence, the lower the option in the ladder, the higher the carbon dioxide emission due to incomplete burning. Negative health consequences also decrease as we move up in the ladder rung, although prices of fuel also increase correspondingly. Given the poverty landscape in a typical African city, we hypothesize in this study that energy ladder is consistent with the gradient of poverty with the city centre occupying the lowest rung while the highest rung is occupied by the dwellers of the periphery. The spatial dimension as hypothesized here has received very little attention over time.

Literature review: A major challenge in the energy environment and health research is that health has generally not played an important role in policies outside the health sector except where a high level of under standing about the relationship with health already exists. Hence, energy health nexus had been poorly explored. From the wreckage of the little research, it is possible to discern the following understanding. As a rule, pollution increases the cheaper the fuel (Smith and Liu, 1994); traditional non-commercial fuels like wood, charcoal and dung which form about 80% of the fuel source for people and household heating in SSA are more hazardous to human health (Listordi and Doumani, 2004). This is because such fuels, depending on the type and length of exposure are direct sources of contact between humans and particulates oxides of sulphur and nitrogen, carbon monoxide, fluoride, aldehydes and other hydrocarbons. Moreover, researches have shown that whereas cooking is a relatively minor end use of energy in industrialized economies, constituting <20%, it is the largest end-use of energy in the SSA accounting for >75% of such uses. Thus the environmental health burden as a percentage of the total disease burden is highest in SSA. This burden is about 27% compared to 18% in Asia and <5% in industrialized nations (Lvovsky, 2001; Smith, 1999). Poverty is also highest in SSA.

Among all environmental risks to human health, indoor air pollution is well recognized as a traditional hazard which is also related to poverty. The IAP related DALYs in 1990 reached about 5.5% for SSA (World Bank, 2000; Weil *et al*., 1990). According to Bradley (1992), the literature on 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 use accounts for 4.7% of deaths in developing countries and 4.3% of disability adjusted life years. Solid fuel comes third after malnutrition (14.9% of deaths, 18% of DALYs) and water supply, hygiene and sanitation (6.7% of deaths and 7.6% of DALYs) (Smith and Mehtra, 2000). Another area of focus in public health investigation of the risk from environment and energy in particular is the high risk groups children that are exposed to risks due to occupation, the elderly and the women.

In each case, each of these groups are said to suffer singly or jointly, the health impact of energy related to disease and conditions of air pollution, injuries, stress and other conditions as well as vector related diseases. It is important to note that the literature on gender and energy often gives passing references to health which rarely examine health as a priority and are therefore not followed by any rigorous health related analysis. A comparison of the literature in the areas of IAP and outdoor air pollution also shows that research in the former is still in its infancy (Listordi and Doumani, 2004). The implication of this includes the fact that researches have focused more on the developed countries whose major preoccupation is the pollution that are generated from industrial activities rather than the activities at the micro level like the household. It is the household energy use in the developing countries that has the highest contribution to IAP. Global Forum for Health Research (1999) gave an over riding reason for this development namely that much general information about environmental health is based on conditions in developing countries reflecting that the driving forces in research development and technology largely emanates from the industrialized world. About 90% of the US$56 billion invested in health research and development by the public and private health sectors goes to research concerning only 10% of the world population (Committee on Environmental Health, 1999). Hence in the developing countries, particularly of the SSA, four major areas in the energy sector are generally described as the uncharted by Listordi and Doumani (2004). These include:

- The quantification of the full burden of diseases from dependence on biomass fuels. In this area, health damages are underestimated focusing on the ARI (Acute Respiratory Infections)
- Valuation of the full economic burden of the disease and possible benefits of energy projects are also poorly developed
- Lack of appropriate shift in paradigm of policy response
- A better understanding of socio-economic underpinning of behavioral change. Here, very little have been done to tap community efforts at self-help in reducing harmful exposures to smoke or improving household economic decision making

Added to the above is the lack focus on the spatial manifestation of the energy ladder. The ladder is an economic framework whose rungs are developed based on overall changes in well being. According to the ladder, as people climb the energy ladder as incomes increase, households buy cleaner fuels, spend less time gathering fuels and are subjected to lower level of harmful emissions (Listordi and Doumani, 2004; Smith and Liu, 1994). The concern in this study is to descibw the spatial manifestations of the energy ladder at a micro level of the city. Thus, the challenges in this study include attempting answers to the following questions; what factors determine the type of energy used in developing country cities and what are the health consequences of the households energy decisions. Findings from the study are expected to assist in the appropriate targeting of areas for interventions and that leading to required paradigm shift in policy response as suggested by Listordi and Doumani (2004).

MATERIALS AND METHODS

The setting for this study is Ilorin metropolis, the capital city of Kwara state in Nigeria. The city is located on latitude 8°30'N and long. 4°35'E, marking simultaneously the cultural and ecological divide between the south-western forest and Yoruba dormant zone and the northern grassland and hausa/fulani zone of the country. The vegetation is in most parts guinea savanna interspersed by trees of different species. The climate is tropical wet and dry characterized by a distinct wet and dry season. The mean annual temperature is often above 26°C with at least 5 h of daily sunshine. The mean annual rainfall is about 125 mm within the city, it is possible to delimit, even if roughly, residential groupings determined by both housing density and their crowding index. The changing economic base of the city is also a general framework through which the growth of the city can be explained. Hence, its role as provincial headquarter since the colonial period, state capital since 1967 and the economic effects of the 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 towards in its different directions and at different times and rates.

The physical growth generated through these momentums also translates into significant changes on the population of the city. The population of the city was a few 36,000 people in 1911, 208,000 in 1963 and about 1 million in 2000. This shows a growth rate of 2.8% per annum. Although, the population of the city might have changed significantly in size, the residential characteristics of its people have remained geographically stable. In other words, a geographically discernible pattern exists of the structure of people living in different parts of the city. This determined often by the levels of income and ethnic affiliation of the people. Hence, the natives who possess their family houses in the interior areas 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 CBD which is interspersed by native houses. Hence, commercial nerve centres developed outside the city centre and comprises of early migrants and early movers from the city centre. The third is the urban frontier comprised of the early 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 before is divided into 20 traditional wards for administrative purposes and adopted in this study for analytical convenience.

The methodology of data collection in this study employs a structured questionnaire to elicit information from 500 households sampled from the 20 traditional wards. The 25 households were sampled using a stratification of the homes from the geometric centre of each ward. From such centres, one out of every 10 households were sampled and the heads of such households were prime targets.

In the absence of the head or due to any inability on his/her part, one person among the household members who was so assigned by other members was interviewed. The questions were drawn to reveal the socio-economic circumstances of households as well as how this affects their choice of domestic energy consumption.

The questionnaires also include a recollection of common household illness and diseases including the first major steps when such illnesses occur. Both descriptive and inferential statistics were used to analyze the responses from this survey.

Analytical procedure

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 listed and defined.

Household and household head characteristics:

- Gender of household heads was taken as the number of female headed households
- Education of household head taken as number of households with illiterate heads. Here, literacy is defined as possession of a minimum of secondary education
- Household size was calculated as the total number of household members reported by all the sampled households in each ward divided by the total sample (25) for the ward
- Occupation of household head is taken as the total number of household heads that indicated a non-urban occupation as their major occupation, e.g., farming

Residential quality:

- Connection to the central electricity measured as the total number of households not connected to the central electricity per ward. Note that this variable was relegated because the survey showed that only one household was not connected to the central electricity
- Number of households using unclean energy for domestic cooking. This is defined as the total number of households using firewood, charcoal, saw dust for cooking domestic food
- Number of houses without separate kitchen. In this category are houses without cooking places located within the house or houses with one kitchen shared by several households. This increases the tendency for households to identify other convenient points, even if not appropriate for cooking
- 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 and hence its resultant health effects. Cooking in other places like front of the house or in a cooking place located outside the house may possess some negative health implications but are not counted here as possessing significant impacts for IAP
- Instrument 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, generation and emission of carbon dioxide and carbon monoxide and other hydrocarbons with dare consequences for households and neighbourhoods

Pollution related health problems:

- It is difficult to obtain a definite of IAP from such qualitative sources as household survey. However, it is possible to query some household health parameters that may be symptomatic of IAP in households. In this study, seven of such household parameters 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 3 months in 1 year (CUFTHREE)
- Bring out blood tinted spittle (BLODSPIT)
- Report chest illness in 1 year (CHESTILL)
- Possessing watery or blood shot eyes (WATEREYE)

The notations in parentheses are relevant to model 2 is as the presence of these indicators in different combinations is suggestive of the presence of IAP when other factors act in coincidence to determine the magnitude and intensity.

Multiple regression models were used to determine the impact of household characteristics on the use of unclean energy and the consequences of energy use on the reported proxies of IAP.

The models:

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

$$EU = f(HHS) \quad (1)$$

Where:

EU = Energy Use

HHS = Household Head's Structure proxied by headship characteristics

Thus,

$$HHS = f(OccHH, HHsize, EDHH, FHH) \quad (2)$$

Substituting Eq. 2 into 1:

$$EU = f(OccHH, HHsize, EDHH, FHH) \quad (3)$$

Where:

OccHH = Occupation of household head proxied by number of households in non-urban occupation

HHsize = Household size

EDHH = Level of education of household head

FHH = Proportion of households headed by female

Based on Eq. 3, we established a multiple linear relationship of the form:

$$EU = \beta_0 + \beta_1 OccHH + \beta_2 HHsize + \beta_3 EDHH + \beta_4 FHH + e \quad (4)$$

Where:

β_0 = The intercept

β_1-β_4 = Estimation parameters defined earlier

e = Residual error term

Model 2: The second model examines the impact of the use of unclean energy on the reported pollution related health problems. The model is of the form:

$$EU = f(IAP) \quad (5)$$

Where IAP is the Indoor Air Pollution proxied by seven selected variables as indicated before with:

$$IAP = f(CUFMOR, CUFEVEN, SPITTLCUF, CUFTHREE, BLODSPIT, CHESTILL, WATEREYE) \quad (6)$$

Thus:

$$EU = f(CUFMOR, CUFEVEN, SPITTLCUF, CUFTHREE, BLODSPIT, CHESTILL, WATEREYE) \quad (7)$$

The regression equation:

$$\alpha_0 + \alpha_1 CUFMOR + \alpha_2 CUFEVEN + \alpha_3 SPITTLCUF + \alpha_4 CUFTHREE + \alpha_5 BLODSPIT + \alpha_6 CHESTILL + \alpha_7 WATEREYE + e \quad (8)$$

Where:

α_0 = Intercept

α_1-α_7 = Estimation parameters

e = Residual error term

In the estimation of the models, 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 other wise 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 significant of the regression analyses and the significant of each independent variable. Thus, in the two models, the behaviour of the independent variables is that β_1-β_4>0 and α_1-α_7>0. In other words, we expect positive values for the estimation parameters in both models.

RESULTS

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

Correlates of energy use among households in Ilorin (Model 1): As shown in Table 1, the model shows 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 significant, the F-statistics shows that the model is useful in the determining if any significant relationship exists between use of energy use and selected characteristics of heads of households; the calculated F (3.50) is greater than the table value of F (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 no positive relationship with the use of unclean energy.

This is suggested 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 is suspected to be because female headed households are more often smaller than those headed by males. Thus, when household sizes are smaller, the energy demand for domestic use is usually low and hence heads are able to afford cleaner energy carriers for cooking.

This is corroborated by the finding 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 non-urban occupation is likely to increase the lower level of education; hence, it follows that illiterate heads of households engage more in non-urban occupation like farming and use more of unclean energy. The source indicated by households in the survey also shows that 39% of households obtained their unclean energy types from farms.

Table 1: Multiple regression analysis of the correlates and health consequences of urban energy use in Ilorin, Nigeria

Explanatory variables	Models 1 (t-value)	2
Intercept)	7.05 (1.45)	-
OccHH	0.52 (1.53)	-
HHsize EDHH	0.44 (0.88)	-
FHH	0.31 (1.08)	-
UFMOR	-0.61 (-1.90)	-
CUFEVENSPITCUF	-	0.53 (0.89)
CUFTHREE	-	0.34 (0.70)
BLODSPT	-	-0.80 (-0.8)
CHESTILL	-	1.45 (1.46)
WATEREYE	-	-0.11 (-0.12)
R^2	-	0.51 (0.89)
F	-	0.33 (1.12)
No. of cases	0.48	0.45
	3.50	1.71
	500	500

Health consequences of indoor air pollution (Model 2): Model 2 shows that the selected proxies of indoor air pollution give 45% of the explanation. The F-statistics also shows that the model is useful in determining the relative contribution of energy use to indoor air pollution. This is because F-calculated is greater than the table value of F at 5% level of significance (F_{cal} = 1.89>F_{tab} = 1.64). Among the seven proxies of IAP, two were shown to possess no positive relationship with unclean energy use. These include bringing out of spittle when respondents cough and respondents noticing bloodstain 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 the 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 3 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 study.

DISCUSSION

This study examines the nature and magnitude of explanation on use of energy use that could be attributed to household characteristics on one hand and the implications of this for household health in cities. The study implies that the household scale is important in the scenario of IAP and the resultant health consequences. It also shows that the use of unclean energy among urban households is confounded with health related problems of IAP. Public health in developing countries stands to benefit immensely from the realization that the more important health problems come from indoor exposures to biomass fuel where energy can play a major role when unclean energy technologies are used. This exposes a number of research and policy challenges for developing countries. First, the links between and among poverty, household characteristics, biomass fuel and environmental health risks is poorly understood. Thus, research attention should be focused on the exploration of these links. For instance, effort must be made to quantify the full burden of respiratory diseases from IAP and of other health effects from biomass dependence.

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 IAP. Currently, studies are scanty that explore the promotion of behavioral changes. To reverse this trend, there must be a shift in the on-going policy and research paradigms in the third world. In other words, before the widespread campaign against unwholesome water sources and filthy environment, water and sanitation problems seemed intractable.

Behavioral change on water and sanitation in terms of hygiene education had led to significant reduction in the level of ignorant and consequently in diarrhea deaths and diseases. Part of the campaign includes that diarrheas was not an automatic part of childhood and that mothers could prevent their children getting sick and dying through them. A similar policy attention is required in the area of energy and IAP. There must 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 care free on the part of the prime victims women.

CONCLUSION

In this study, measures that reduce exposure to smoke like presoaking of beans and building fires in sheltered areas away from homes should be adopted. Governments of developing countries must make efforts to reduce the prices of energy to the levels affordable to the poor. This cannot be done except governments realize and appreciate the strategic position of the energy sector in the generation of IAP and health problems.

IMPLICATIONS

It has been shown that structural characteristics of households are important determinants of use of unclean energy. Moreover, these unclean energy carriers posses far reaching implications for IAP and human health particularly in the third world. 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 IAP. 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 done, appropriate targeting of population and households will be possible for intervention programmes. To generate negative health consequences, the location of household cooking spot is a very important attribute. In most houses especially in the third world inner cities, there are no separate kitchen and houses are usually multi-family dwelling units. Indeed, where there are what can be called kitchens, they are located at the extreme end of long house; in some cases, house occupants are forced to travel several metre from their rooms to get to the common kitchen. Hence, in most cases, families prepare their food in front of their room using parts of a common passage in multi-family dwelling units. The smoke generated from such cooking habit by several households in one housing unit can be enormous depending on the instrument for cooking and the duration of the activity.

An important factor is the prices and availability of clean energy carriers. Gas and electricity have been adjudged the cleanest energy technologies whereas the prices of gas and kerosene have increased >10 folds since 1999 in Nigeria. The levels of poverty of people have also soared since then. These taken together and considering the strategic nature of energy for cooking, households are forced to adopt the unclean carriers of energy for cooking. In he same vein, electricity supply to most Nigerian cities had declined tremendously with many parts having <12 h of electricity in 1 week. For many households, electricity is indeed not a consideration for cooking domestic foods. Trie finally, use of clean energy is a major issue in the realization of the Millenium Development Goals (MDGs) to which developing countries have subscribed. It is recommended that for countries to reduce maternal and child mortality, TB prevalence and increase environmental sustainability, urban energy purity must be emphasized.

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