Effects of Cooking Fuels on Acute Respiratory Infections in Children in Tanzania

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Abstract: Biomass fuels, charcoal and kerosene are the most used cooking fuels in Tanzania. Biomass fuel use has been linked to Acute Respiratory Infections (ARI) in children. It is not clear whether the use of charcoal and kerosene has health advantage over biomass fuels. In this study, the effects of biomass fuels, charcoal/kerosene on ARI in children under five years old in Tanzania are quantified and compared based on data from Tanzania Demographic and Health survey conducted between 2004 and 2005. Approximately 85% and 15% of children were from biomass fuels and charcoal/kerosene using homes respectively. Average ARI prevalence was about 11%. The prevalence of ARI across various fuel types used for cooking did not vary much from the national prevalence. Odds ratio for ARI, adjusting for child's sex, age and place of residence; mother's education, mother's age at child birth and household living standard, indicated that the effect of biomass fuels on ARI is the same as the effect of charcoal/kerosene (OR 1.01; 95% CI: 0.78-1.42). The findings suggest that to achieve meaningful reduction of ARI prevalence in Tanzania, a shift from the use of biomass fuels, charcoal and kerosene for cooking to clean fuels such as gas and electricity may be essential. Further studies, however, are needed for concrete policy recommendation.

Keywords: Biomass fuels, Cooking fuels, Acute Respiratory Infections, Children.

Introduction

Traditional biomass fuels (wood, agricultural wastes and animal dung) are the major source of energy in developing countries. Two billion people use biomass fuels as their main source of domestic energy [1]. It is estimated that about 30% of urban households and 90% of rural households in developing countries rely on traditional biomass fuels as the major, or only, source of domestic energy [2]. In Tanzania, biomass fuels account for more than 90% of primary energy supply in the country [3].

Biomass fuel use is the major cause of indoor air pollution in developing countries. Since biomass fuels are the dirtiest fuels, their combustion which mainly takes place in poorly functioning indoor stoves leads to high levels of a number of health damaging pollutants such as particulate matter; carbon monoxide; nitrogen oxides; formaldehyde; benzene; 1,3 butadiene; polycyclic aromatic hydrocarbons and many other toxic compounds [4]. Exposure to these pollutants in developing countries is reported to be higher in women and children [5].

Exposure to pollution from biomass fuel combustion has been identified as an important health risk threat in developing countries [6]. Cooking with biomass fuels and coal is estimated to cause 3% of all diseases worldwide [7]. It has been shown that exposure to biomass fuel smoke is responsible for a number of respiratory diseases such as Acute Respiratory Infections (ARI), Chronic Obstructive Pulmonary Disease (COPD), Tuberculosis and Asthma; Low Birth Weight; Cataract and Blindness [8]. ARI are more common in children [9] and are a major cause of pediatric hospital consultations and admission of children to hospital [10]. ARI are estimated to cause three

to five million deaths annually [11] mainly in developing countries.

Several studies have tried to assess the association between biomass fuel use and respiratory infection morbidity and mortality [1-2, 12-18]. Exposure to biomass fuel smoke in these studies was ascertained in different ways. Studies conducted in Zimbabwe and India used cooking fuel type to group children into different categories of exposure [17-18]. The reference group in these studies was children from homes using clean fuels such as gas and electricity for cooking.

In Tanzania, the use of gas and electricity for cooking is not common. Charcoal and kerosene are other fuels widely used after biomass fuels. The use of kerosene and charcoal is skewed towards urban areas while biomass fuels are heavily used in rural areas. Charcoal is much cleaner than raw wood or biomass fuels [19] but it is not clear whether its use has health benefit over raw biomass. Kerosene can be burnt very cleanly in pressurized burner but is often used in ways which raise some health concerns. Despite the fact that the three fuel types dominate many kitchens of Tanzania and other developing countries; to the best of our knowledge no studies have compared the effects of the three fuels on ARI. In this study, the effects of biomass fuels on ARI are examined to test the hypothesis that the effect of biomass fuel use for cooking is higher than the effect of charcoal or kerosene on ARI among children in Tanzania.

Methods

Study Subjects

The study utilized information on 5224 children under 5 years living in a nationwide cross-sectional sample of 10312 households included in the Tanzania Demographic and Health Survey conducted between 2004 and 2005 (2004-5 TDHS). The survey, implemented by the Tanzania National Bureau of Statistics (NBS) in collaboration with the Chief Government Statistician-Zanzibar, collected demographic, socio-economic and health information from all 26 regions making up the United Republic of Tanzania. The principal objective of the survey was to collect data on household characteristics, fertility levels and preferences, awareness and use of family planning methods, childhood mortality, maternal and child health, breast feeding practices, antenatal care, childhood immunization and diseases, nutritional status of young children and women, malaria prevention and treatment, women status, female circumcision, sexual activity, and knowledge and behavior regarding HIV/AIDS and other sexually transmitted diseases. Given the broad nature of variables collected, the survey provides good data for various analytical studies. The details of the survey are available on the NBS website accessible at http://www.nbs.go.tz

Data Collection and Quality Assurance

Men, women and household questionnaires were used for data collection. The questionnaires were based on the model questionnaires developed my MEASURE DHS program and were adopted in a series of stakeholders' technical meetings which drew representatives from the government, non-governmental organizations and international donors. The questionnaires were translated from English to Kiswahili.

Supervisors, field editors, male and female interviewers, quality control personnel and trained nurses from the ministry of health were recruited and trained to work as field staff during data collection. Field editors were responsible for reviewing all questionnaires for quality and consistency. Quality control personnel also independently interviewed certain households after departure of the interviewers. NBS officers periodically visited field staff to review their work and monitor the quality of the data being collected.

Response Variable

A women's health questionnaire administered to the survey eligible women (15-49 years of age) elicited information on the respiratory health of children under five years. For each child, the mother was asked if the child suffered from cough in the last two weeks preceding the survey. For children who had cough, the mother was additionally asked if the child, when sick with cough, breathed faster than usual with short, rapid breaths. The 2004-5 TDHS described children who suffered from cough together with short and rapid breathing at any time during the last 2 weeks prior to the survey as having ARI. Suffering from ARI is the dependent variable used in this study.

Predictor Variables

The survey also gathered information on fuel type used for cooking by the selected households. To elicit this information the question "what type of fuel does your house usually use for cooking?" was asked. The question was then followed by a list of different fuel names to choose from. The fuels included electricity; bottled gas, biogas, kerosene, firewood/straw, dung, crop residuals, and others. Information on cooking fuel types was used to categorize children into two groups: group of children from homes using biomass fuels (firewood, straw, dung and crop residuals) and group of children using charcoal or kerosene. Children from homes cooking on fuels other than biomass fuels, charcoal and kerosene were excluded. Use of biomass fuels or charcoal/kerosene is the main independent variable of the study.

Statistical Analysis

Multicollinearity was tested prior to the examination of the association between ARI and fuel type used for

cooking. High correlation was observed between household number, region and zone of child's residence. Correlation was not observed between household number and ARI in children suggesting that there was no clustering of ARI in children from the same household. To avoid the effect of multicollinearity, region of residence was dropped from the analysis. Clustering of ARI in children at mother's level was avoided by using children born at last birth i.e. only the youngest child per mother was included in the analysis.

To assess the effect of cooking fuel on ARI, logistic regression analysis was conducted using SPSS. Control variables adjusted for in the analysis include zone of child's residence (Eastern, Zanzibar, Western, Northern, Central, Southern highlands, Lake and Southern), child's residence type (Urban, Rural), sex of child (male, female), age of child in months (0-5, 6-11, 12-23, 24-35, 36-59), mother's age at child's birth in years (15-24, 25-34, 35-49), mother's level of education (no education, primary, secondary+), child's residence in the two sides of the United Republic of Tanzania (Tanzania Mainland, Tanzania Zanzibar) and living standard of the household in which the child resides (low, medium, high). Calculation and classification of household living standard was done as shown by Mishra [17]. Dummy variables were created by categorical subcommand to indicate non-dichotomous variables.

Results

The distribution of children with respect to various characteristics is summarized in Table 1. Of all the children used in the analysis, approximately 85% of them lived in biomass fuel using homes. The male to female children ratio was almost 1. Majority of the children were 12-23 months old. The children were predominantly from Tanzania Mainland and rural areas (80%) reflecting the place where the majority of Tanzanians live. About half of the children were born to mothers between 25-34 years old and were from low living standard households.

The overall prevalence of ARI in children was approximately 11%. Prevalence in children from homes cooking on biomass fuels and from homes using kerosene or charcoal was more or less the same but a little higher among children from biomass fuels using homes. Prevalence was to some extent higher in boys (11%) than in girls (10%). Children less than six months old less likely suffered from ARI (7%) than children from higher age groups.

ARI was more prevalent in rural areas (11%) than in urban areas (9%). Children whose mothers have attained education recorded higher ARI prevalence than those born to mothers without education. ARI prevalence did not vary much with mother's age at child birth but was somehow lower in children from medium living standard households (10%) than in children from low and high living standard households.

Table 1: Sample distribution and ARI prevalence in children under 5 years old two weeks prior to TDHS 2004-5.

Characteristics	Sample distribution		Prevalence of ARI	
	No.	%	No.	%
Tanzania	5524*	100	550	10.53
Cooking fuel type				
Biomass fuels	4432	84.83	477	10.76
Kerosene/Charcoal	792	15.17	73	9.20
Sex				
Male	2595	49.68	291	11.21
Female	2629	50.32	259	9.85
Child's age (months)				
0-5	832	15.90	56	6.73
6-11	907	17.37	127	14.00
12-23	1521	29.13	167	10.98
24-35	1029	19.69	110	10.69
36-59	935	17.91	90	9.63
Union side				
Tanzania Mainland	4257	81.48	436	10.24
Tanzania Zanzibar	969	18.52	114	11.79
Residence				
Rural	4227	80.90	463	10.95
Urban	997	19.10	87	8.73
Mother's education				
No education	1389	26.58	137	9.86
Primary	3356	64.24	358	10.67
Secondary+	479	9.17	55	11.48
Mother's age at child birth				
15-24	1992	38.10	208	10.36
25-34	2261	43.31	244	10.79
35-49	971	18.60	98	10.09
Living standard				
Low	3290	62.97	360	10.94
Medium	1611	30.86	156	9.68
High	322	6.17	34	10.55

*One case was missing for living standard variable

Crude and adjusted odds ratios (ORs) of suffering from ARI are presented in Table 2. Of all the variables, only child's age was significantly associated with ARI. The unadjusted odds ratio (OR) of having suffered from ARI for children living in households using biomass fuels compared to those living in households using kerosene or charcoal is 1.19 (95% CI: 0.92-1.54).

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Table 2: Odds ratio estimates of effects of fuels used for cooking on ARI prevalence in children.

Characteristic	OR (95%CI)	
	Unadjusted	*Adjusted*
Cooking fuel type		
Biomass fuels	1.19(0.92-1.54)	1.01(0.78-1.42)
Kerosene/Charcoal*	1.00	1.00
Sex		
Male*	1.00	1.00
Female	0.86(0.72-1.03)	0.87(0.73-1.03)
Child's age (months)		
0-5*	1.00	1.00
6-11	2.26(1.62-3.13)	2.28(1.64-3.17)
12-23	1.71(1.25-2.34)	1.73(1.26-2.37)
24-35	1.66(1.18-2.32)	1.68(1.20-2.35)
36-59	1.47(1.04-2.09)	1.53(1.08-2.17)
Union side		
Tanzania Mainland*	1.00	1.00
Tanzania Zanzibar	1.17(0.94-1.46)	1.03(0.73-1.04)
Residence		
Rural*	1.00	1.00
Urban	0.78(0.61-0.99)	0.78(0.57-1.05)
Mother's education		
No education*	1.00	1.00
Primary	1.09(0.89-1.34)	1.18(0.96-1.47)
Secondary+	1.18(0.85-1.65)	1.32(0.91-1.92)
Mother's age at child birth		
15-24*	1.00	1.00
25-34	1.05(0.86-1.27)	1.01(0.83-1.23)
35-49	0.97(0.75-1.25)	0.92(0.71-1.19)
Living standard		
Low*	1.00	1.00
Medium	0.87(0.71-1.06)	0.82(0.65-1.03)
High	1.00(0.66-1.39)	0.90(0.57-1.42)

*Reference category

The effect of biomass fuels on ARI is reduced to somewhat the same level as that of charcoal and kerosene when control variables are adjusted in the analysis (OR 1.01; 95% CI: 0.78-1.42). Unadjusted and adjusted ORs showed less risk of ARI in girls than in boys. The odds ratio of having suffered from ARI is almost two times higher in children aged 6-59 months than among younger children. The odds ratio of having ARI declined somehow for children older than 11 months but remained significantly higher suggesting that children less than 6 months old are less exposed to ARI risk factors than their older counterparts. Living in Tanzania Mainland or Tanzania Zanzibar did not have effect on ARI (OR 1.03,

95% CI: 0.73-1.04). Children in urban areas were 22% less likely to have suffered from ARI than children in rural areas (OR 0.78; 95% CI: 0.57-1.05).

Elevated ORs was observed for mother's education. Children born to mothers aged 35-49 were 8% less likely to have suffered from ARI than those born to younger mothers. Increasing household living standard reduced the prevalence of ARI, but reduction was higher for medium living standard (18%) than for high living standard (10%). Lower reduction of ARI prevalence by high socioeconomic standard compared to medium standard can be attributed to the fact that children from high socioeconomic status are more exposed to modern health hazards such as industrial gases, vehicular gases, paints and fumigation than children from middle living standard homes.

Discussion

As reflected by the number of children in the study, biomass fuels are the major source of energy used for cooking in Tanzania. The fuels have been referred to as high pollution fuels while charcoal and kerosene have been referred to as medium pollution fuels [17-18]. Results in this study show that mother reported prevalence of ARI in children does not vary much when distributed across various risk factors (significance test not conducted). The prevalence of ARI in biomass fuels using children in Tanzania is lower than that described in analogous studies conducted in Zimbabwe and India [17-18].

Positive association between exposure to biomass smoke and ARI incidence and prevalence has been reported in many studies. A few studies, however, have failed to establish a relationship between smoke and ARI [17]. A follow-up study in Kenya developed an exposure-response function between exposure to particles from biomass fuels combustion and ARI [1]. A review of literature which interpreted evidence on association in terms of epidemiological and toxicological framework suggested that the evidence of association should be considered causal [11].

Logistic regression analysis in this study revealed that the effect of high pollution biomass fuels use on ARI prevalence among children under five years old in Tanzania is the same as that caused by the use of charcoal or kerosene irrespective of sex of the child, age of the child, child's place of residence (Tanzania Mainland/Tanzania Zanzibar, Zone, Urban/rural), mother's education, Mother's age at child birth and household living standard in which the child lives. Even though charcoal and kerosene are considered as medium pollution fuels, it may be true that their emissions produced when the fuels are used are below the levels which can provide substantial health benefits relative to the use of biomass fuels. Since the association between biomass fuel smoke exposure and ARI is considered causal [11], the policy implication of this study is that to achieve meaningful attenuation of risk of ARI caused by cooking fuels in children in Tanzania, a shift to clean

fuels such as gas and electricity may be essential. However, further studies with measurement of pollution for various fuel types and clinical diagnosis of ARI are vital for concrete policy recommendation.

The highest effect of age on ARI was observed in children between 6-11 months old. Reasons for higher effect in this age group have been explained [17] but it can further be urged that unlike their younger counterparts, children in this age group are old enough to be carried on their mothers' back which may increase the likelihood of exposure to smoke whilst their disease resistance system is less developed than their older counterparts leading to higher ARI rate. Boys were observed to be affected more than girls. While it is not known whether elevated risks of ARI in boys have biological meaning, similar results for sex have been observed in India [18]. ORs also indicated somehow elevated risks of ARI in association with mother's education which can be an indication of either poor memory by uneducated mothers on the past health history of the children leading to underestimation of cases or underestimation of cases as children from uneducated mothers are more likely to succumb to death from ARI. Living in rural areas was also associated with higher prevalence of ARI in relation to living in urban areas. The higher odds ratio of ARI for rural children can be attributed to poor access to medical care and low socioeconomic standard.

One thing worth to mention here is that when considered alone, fuel type and other risk factors (with exception of age) was found not to be a significant determinant of ARI in children. Lack of statistical significance can be attributed to the fact that many factors such as nutritional status, birth order, number of people living in the house (crowding), birth weight, prenatal diseases, breast feeding and child care may as well influence the occurrence of ARI in children. The use of mixed fuels showed a significant positive association with ARI in children in India [18]. Lack of difference in effects of fuels on ARI may partly be due to the fact that many homes in Tanzania use a combination of different fuels to cook. Other sources of pollution with similar health effects may as well affect the results if not well accounted for. The 2004-5 TDHS defined ARI as presence of cough accompanied with short and rapid breathing. Under field conditions in less developed countries the WHO defines AURI to include any combination of cough with or without fever, blocked or runny nose, sore throat, and/or ear discharge. Since it is difficult to distinguish between Acute Lower Respiratory Infections (ALRI) and AURI without clinical diagnosis the word ARI which includes both ALRI and AURI were adopted for the purpose of this study. Association between ARI (ALRI and AURI) and biomass smoke have been reported [1, 8, 20]. Similar effects between biomass fuels and charcoal/kerosene on ARI in this study cannot probably be explained by failure to separate ALRI from AURI.

While this study has advantage of using a large national representative sample, the following limitations have to be kept in mind when considering the policy implication of the study. First, as mentioned earlier, children in this study were grouped based on whether the children were living in homes cooking on biomass fuels or charcoal/kerosene. It is common in Tanzania to find one house using more than one fuel e.g. charcoal and kerosene. Such grouping of children without more information on children from homes using a combination of several fuels may lead to different effect values. Second, ARI was assessed by the use questionnaire which required mothers to explain on the health of their children with respect to ARI in the period two weeks prior to the survey. Since this is not an objective way of collecting health information, the method used to collect health information may have caused underestimation or overestimation of ARI frequency in children. Third, it may be possible that some risk factors used in the analysis also work in tandem with each other to influence the occurrence of ARI in children. Failure to assess interaction in this study may mislead the results. Forth, as in many studies of this sort, this study may have failed to incorporate into analysis all potential confounders. Some of these factors may include nutritional status of the child, birth order of the child, religion of child's mother, ventilation of the house or kitchen, child care practice, prenatal health, birth weight of the child, number of people living with the child in the same house (crowding) and environmental tobacco smoke. However, it is hereby thought that nutritional status, religion, birth weight, child care practice and number of people in the house may correlate with mother's education and household living status. Birth order may probably be explained by mother's age at child birth. Tobacco smoking is rare among women in Tanzania posing little health risk to the children. Thus, exclusion of these variables in the analysis may not have significantly affected the results.

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