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Household Fuel Use and Acute Respiratory Infections Among Younger Children

An Exposure Assessment in Shebedino Woreda, Southern Ethiopia

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Acronyms

ARI	Acute Respiratory Infection
ALRI	Acute Lower Respiratory Infection
CO	Carbon monoxide
CO2	Carbon dioxide
CSA	Central Statistical Authority
DALYs	Disability Adjusted Life Years
FGDs	Focus Group Discussion
KAP	Knowledge Attitude and Practice
NOx	Nitrogen oxides
PAH	Polycyclic aromatic hydrocarbon
PM_{10}	Particulate matter with an aerodynamic diameter of less than 10 μm
$PM_{2.5}$	Particulate matter with an aerodynamic diameter of less than 2.5 μm
SFU	Solid Fuel Use
SNNPR	Southern Nations, Nationalities and Peoples Regional State
SO_x	Sulfur oxides
WHO	World Health Organization

Abstract

Indoor air pollution caused by the indoor burning of biomass fuels has been associated with increase risk of acute respiratory infections among children less than five years old in developing countries. This research was focused on the public health importance of solid fuel use in households, with the objective of investigating the effect of household fuel use on acute respiratory infection in younger children at Shebedino Woreda.

The study design was cross-sectional, which employed an exposure assessment approach, collecting detailed primary data on several household-level exposure indicators through the administration of a questionnaire and Checklist for ARI screening in 405 households, together with qualitative data through Focus Group Discussion —to supplement the knowledge, attitude and practice (KAP) response. The households were selected proportionally using systematic sampling scheme and guardian/mothers were selected for the interview. Data were collected during January to February 2006. Ten data collectors, who were native speakers and had similar experience were employed and trained by the principal investigator and a Pediatrician for two days extensively in interviewing techniques, data recording, and approaches to promote health education and child health screening. The questionnaire responses were entered into software called EPI and analyzed using Statistical package for Social Sciences (SPSS) software.

ARI prevalence of the study area (21%) was found to be lower as compared to the national figure (24%) in 2000. According to spearman's correlation matrix for the explanatory variables, the poverty line was correlated with characteristic of the kitchen and kitchen ventilation. Moreover, educational status of head of households was correlated with characteristic and ventilation of the kitchen. Conversely, there was no sufficient evidence for the significant association of ARI prevalence with educational status of head of the household. Further analysis also shows that there was no sufficient evidence for the

significant association of ARI prevalence with residence, means of income, number of rooms, stove type, and kitchen features.

Result from the focus group discussion also revealed that most participants had the concept of health impact due to household fuel use and they also articulated that cow dung and straw would affect their health seriously. Moreover, few participants were not aware of the impact with stove type and over three quarter (75.8%) of the children were kept to stay indoor during the daytime.

The study approach appears to demonstrate a relatively consistent association between child handling practice while cooking and childhood ARI. The existing environmental and socioeconomic factor in the study area has a considerable potential to contribute for environmental threats to the health of children. It will be no surprise that exposure to particulate matter can be high in the rural indoor areas.

The research suggests further analysis in risk characterization – an in-depth understanding of the potential for child health risks in terms of exposure potentials.

Key Words: *ARI, Solid Fuel, Stove Type, Ventilation, KAP, Shebedino*

1. INTRODUCTION

"To look into some aspects of the future, we do not need projections by supercomputers. Much of the next millennium can be seen in how we care for our children today. Tomorrow's world may be influenced by science and technology, but more than anything, it is already taking shape in the bodies and minds of our children." – Kofi Annan, Secretary-General of the United Nations"

1.1. Background

The connection between wood use, cooking and the epidemiology of respiratory and other illnesses is a topic of active current research. However, a consistent pattern linking energy, environment, and health has already become alarmingly clear [1].

Ninety to ninety five percent of domestic energy in Sub-Saharan Africa depends on biomass fuels, most of it for cooking. In Ethiopia, these fuels are the major sources of energy consumption. For more than 90% of the Ethiopian population the only energy used for cooking, heating and lighting is obtained from biomass, in which 99% is derived from fuel wood, charcoal, crop residue and leaves, fuel wood occupying the leading position [1, 2, 3]. Combustion of these fuels in confined often-unventilated indoor areas and at low thermodynamic efficiency leads to high concentrations of smoke and other pollutants [4, 5].

The dependence on such polluting fuels is both a cause and a result of poverty, as poor households often do not have the resources to obtain cleaner, more efficient fuels and appliances. Reliance on simple household fuels and appliances can compromise health and thus hold back economic development, creating a vicious cycle of poverty [6].

This pollution from solid fuel use is a significant risk factor for acute respiratory infections, which accounts for a remarkable 7% of the global burden of disease [7] and is most firmly associated in younger children[8].

Facilitating improvements in household energy use for two billion poor households worldwide that rely on solid biomass fuels for cooking and heating is a daunting task. But development experts and practitioners around the world now accept that addressing the problem of household energy and related health and environment impacts should become an integral part of poverty eradication and development efforts [8].

The disease burden of a population, and how that burden is distributed across different subpopulations (e.g. infants, women), are important pieces of information for defining strategies to improve population health [7].

1.2. Rationale of the study

Globally, pneumonia and other acute lower respiratory infections represent the single most important cause of death in children under five years. Exposure to indoor air pollution☑ doubles the risk of pneumonia and is thus responsible for more than 900, 000 of the 2 million annual deaths from pneumonia [6, 9, 10]. In Southern Nations Nationality and People's Region (SNNPR), Ethiopia, an acute respiratory infection is among top five killer diseases [11].

The disease burden from solid fuel use (SFU) is most significant in populations with inadequate access to clean fuels, particularly poor households in rural areas of developing countries. Women and their youngest children are most exposed because of their household roles [8, 12].

In many developing countries, there is a heavy dependence on and a growing demand for fuel wood [13, 14]. Like many countries of the developing world, **Ethiopia is experiencing unbalanced situation between its rapid urban growth and the provision of household energy (fuel wood).** The increasing scarcity and cost of household energy, particularly **fuel wood**, threatens the ability of the population even to maintain the already existing poor living conditions [13].

☑ **Indoor air pollution refers to the exposure of household members to toxic emissions from cooking and heating activities and especially in the case of this study from the use of wood, dung and other biomass cooking fuel in traditional mud and stone stoves.**

Despite the magnitude of this growing problem, the health impacts of exposure to indoor air pollution have yet to become a central focus of research, development aid and policy-making [6].

It is therefore, of crucial importance to know the extent and the existing nature of biomass fuel for household energy consumption **for the following reasons [15]:**

- The health burden is high, even though there is uncertainty associated with the exact risk estimates.

- Biomass will continue to be used by a large number of households for the foreseeable future.

- The burden of disease due to indoor air pollution is highly concentrated among the society's most vulnerable groups: women and children in poor rural and urban households.

Significance of the Study

This study makes a firm information base available for analyzing and formulating energy and environmental health decisions for government and non-government institutions and for all concerned bodies at local and national level.

For policy-makers, the research output provides an indication of the health gains that could be achieved by targeted action against specific risk factors. It also allows policy-makers to prioritize actions and direct them to the population groups at highest risk.

1.3. Scope of the study

The research was focused on the public health importance of solid fuel use in households, since this is the single most important situation by which rural people [especially younger children] become exposed to air pollution.

1. Accordingly, estimates of exposure levels need choice of exposure variables. The study did not capture the air pollutant concentration as an exposure variable for Solid Fuels Use for the following reason:
    - Prior studies have shown that indoor levels of air pollutants can be quite high from solid fuels use in developing country households, much higher than health-based standards and guidelines [16].
    - It is prohibitively expensive and time consuming for most local assessments to conduct sufficient indoors air pollution measurements to obtain reliable exposure distribution.

2. The research made use of acute respiratory infection as an outcome variable where it is typically diagnosed on a symptomatic basis, rather than by identification of specific pathogens [17].

3. Moreover the research is focused on younger children (0 – 5 years) for the following reasons:
    - Most studies of environmental health focused primarily on adult populations [18]. Similarly, many of the safety standards are based on data that do not specifically cover risks to children, but children are not little adults [19].
    - Because this age group does not attend school, and is likely to spend more time with their interviewed mothers; which is more likely that the mother knows their symptoms.

2. LITERATURE REVIEW

Energy use and supply is of fundamental importance to society. It is important in every field of man's daily activities such as manufacturing, agriculture, mining and household activities. That means the advancement of human civilization, consisting not only the process of industrialization but also of improvements in the standard of living and public health is dependent upon an adequate supply of energy [5, 20]. In the subsequent sections the characteristics of household energy and their health effect is discussed in detail.

2.1. Characteristics of Household Energy

The largest proportion of energy consumption in everyday human activities is the household sub-sector for different purposes like cooking, lighting and heating. For such activities the various energy sources ranging from biomass (fuel wood, charcoal and tree residues) to electricity are used. In developing countries, however, biomass fuels are still by far the dominant household energy sources, despite the growing scarcity of biomass resources [5, 20].

Over the last 25 years, the trend in global bio-fuel use has changed little, and in some parts of the world where poverty and the prices of alternative fuels such as kerosene and bottled gas have increased, the use of biomass has

increased [21]. According to an estimate as many as 800 million people all over the world were relying on crop residues as principal cooking fuel [22].

Emissions from wood-burning stoves and fireplaces consist of a complex mixture of gases and particles including inhalable PM (particulate matter of diameter less than or equal to 10 micrometers, or PM_{10}), the finer respirable PM ($PM_{2.5}$) and contaminants that contribute to poor air quality and smog, for example sulphur oxides (SO_X), nitrogen oxides (NO_X) and CO. Residential wood-burning emissions also contain carcinogenic compounds, including polycyclic aromatic hydrocarbons (PAH), benzene, formaldehyde and dioxins [23, 24]

This pollution occur when fossil or biomass fuels are used for cooking and heating in crowded and poorly ventilated settings. Of all forms of air pollution worldwide, indoor air pollution from open fires or inefficient stoves is the single greatest cause of ill-health [25, 26] and significantly a risk factor for acute respiratory infections (ARI), which account for a remarkable 7% of the global burden of disease [8].

A report of the World Health Organization (WHO) asserts the rule of 1000 which states that a pollutant released indoors is one thousand times more likely to reach people's lung than a pollutant released outdoors [25, 27].

2.2. Health Effects of Exposure to Pollutants from Solid Fuel Use

A wide range of physical, social and environmental factors influences health. In addition to the production of toxic pollution, the supply and use of household energy in conditions of poverty and scarcity affects health – particularly of women and young children – in a variety of ways that encompass physical injury, lost opportunity for income generation, environmental stress, and many other issues [28, 29].

According to various studies household energy has substantial impact in health of rural poor: globally 1.8 million excess deaths and around 4% of the burden of disease in terms of Disability Adjusted Life Years (DALYs) lost that are attributable to indoor air pollution – most of which falls on the rural poor [30]. More over the disease burden attributable to solid fuel use in sub-Saharan Africa is 4.8% (see table 1).

These health effects of air pollution depend in large measure on the types of pollutants inhaled and the exposure level (i.e., frequency, concentration, etc.) of the child. Estimates suggest that up to 60 per cent of the global ARI burden of disease is associated with indoor air pollution and other environmental factors such as ambient air pollution and housing conditions [25]. Infants and young children, particularly girls, who are often requested to help their mothers in household chores, are most at risk.

Table 1. Annual Burden of Disease Attributable to Solid Fuel Use in 2000

Region	Deaths (thousand)	DALYs (thousand)	Disease Burden (percent)
Sub-Saharan Africa	392	12,300	4.8
South Asia	521	14,200	3.9
India	424	11,500	3.9
East Asia	503	6100	2.5
China	423	5120	2.5
Southeast Asia	37	990	1.6
Indonesia	27	713	1.6
Poor Latin America	26	773	0.90

Source: World Health Report, WHO 2002

Key Health Outcome: *Childhood Acute Respiratory Infections*

Indoor air pollution caused by the indoor burning of biomass fuels has been associated with increase risk of acute respiratory infections among children less than five years old in developing countries [31].

Infants are exposed to pollutants while resting on the backs of their mothers as they tend fires. The small particles in polluted air enter deep into the lungs and respiratory organs, causing viral and bacterial ARI, the most severe being pneumonia. ARI accounts for 67 per cent of deaths in the world's children from birth to 14 years [25]. Irritation that would not significantly affect adults may

result in more severe obstruction and damage in a child's lungs since they are still forming and are more vulnerable [19, 32, 33].

Recent estimates of the burden of disease attributable to use of bio-mass fuels in India put this figure at 5-6 percent of the national burden of disease [34, 35]. Given the wide spread prevalence of solid-fuel use, and the emerging scientific evidence of health impacts associated with exposures to emissions from solid-fuel use, indoor air pollution issues in rural households of developing countries, are of tremendous significance from the stand point of population health.

Conversely, medical and educational research has shown that the development of intelligence, personality and social behavior occurs most rapidly in humans during their first three to four years. It is estimated that half of all intellectual development potential is established by age four [27]. According to recent research, brain development is much more vulnerable to environmental influence than was previously suspected and the influence of early environmental quality on brain development is long lasting [36].

Improvements in cooking and heating technology need to be complemented with simple changes in kitchen configuration and ventilation conditions, which could be among the most cost-effective measures to reduce exposure. Facilitating behavioral changes in women, children and other household

members is another way of reducing exposure and alleviating the associated health impacts. Improving the status of women can be an effective method of promoting markets for better stoves and other household energy-use services [7].

3. RESEARCH QUESTIONS AND OBJECTIVE

The study attempts to address the following hypothetical research questions:

- ***Is exposure variable for Household Fuel Use a health risk to the younger children in Shebedino Woreda?***
- ***What characteristics in Shebedino Woreda modulate exposure to indoor air pollution from household fuel use?***

General Objective

To investigate the effect of using biomass for household fuel use on acute respiratory infection in younger children at Shebedino Woreda

Specific Objectives

- Estimate Acute Respiratory Infections (ARI) prevalence among children below the age five of years in Shebedino Woreda regardless of fuel type used
- Determine the extent to which ARI prevalence among younger children related to household characteristics
- Determine the extent to which ARI prevalence among younger children related to household fuel use
- To describe the knowledge, attitude and practice of caretakers about health impact of household fuel use
- To propose proactive suggestions and provide baseline data for future study

4. STUDY DESIGN AND METHODOLOGY

The study design was cross-sectional, which employed an exposure assessment approach, collecting detailed primary data on several household-level exposure indicators (fuel type, stove type, kitchen type, housing type, ventilation, etc.) through the administration of a questionnaire and a checklist in 405 households, together with qualitative data through Focus Group Discussion — to supplement the knowledge, attitude and practice (KAP) response.

4.1. Study Area and Population

The study area was in the Woreda town, Leku, and peasant associations of Shebedino Woreda. Shebedino Woreda is bordered by Dale Woreda in the South, Awassa Zuria Woreda in the North, Boricha Woreda in the West and Arbe Gona in the East. The total area of the Woreda is 405.36 square kilometer and the average population density is 674 people per square kilometer. The average annual rainfall is 900-1,100 mm and the average temperature of the Woreda is between 18-25 ^{o}C.

Thirty three percent of the Woreda is classified as Dega (highlands) and the remaining 67 % is Woinadega (midlands). The current population of the Woreda is estimated to be 315,354 based on projections from the 1994 census, of which the rural population comprises 283,985 and the urban population 31,369. In

2004, pneumonia is the main disease for younger children in Shebedino Woreda [37].

The study unit included all households with under-five children and whose families are permanent dwellers of the study area for at least one year.

4.2. Sample Size

The sample size was determined using the following formula:

$$n = [(Z\alpha/2)^2 P (1-P)]/d^2 = 405$$

Where,

n = the number of households to be interviewed;

Z = standardized normal distribution curve value for the 95% Confidence Interval, which is 1.96

P = 0.5 proportion of the community

d = the margin of error is taken as 5%

5% contingency is considered for households who may refuse to participate

4.3. Sampling procedures

The Woreda was divided into urban and rural residence for the reason to make out the pattern of solid fuel use with variation in characteristics followed by a random selection of Kebeles and peasant associations. About 405 houses with under five child/children was selected proportionally using systematic sampling

scheme and caretakers/mothers were selected for the interview. Children's date of birth was confirmed with birth certificates or immunization records. Homogenous sampling strategy technique was also used for FGDs (Focus Group Discussion).

4.4. Study Instrument

The survey instrument was a well-structured questionnaire (See Annex II), checklist (ARI) and topic guide for the focus group discussion. The questionnaire was developed after critical commentary discussions had been made by experts, who were from social anthropology, health science, and environmental science (Principal Investigator) background. This specific structured questionnaire (tailored to the social, cultural and economic situations of the study region) was adapted from WHO (8) guidelines for survey of household fuel use. The checklist was developed based on the WHO♦ guidelines - ARI module.

♦ WHO. ARI: programme review for control of acute respiratory infections. Sixth programme report. Geneva: 1993.

4.5. Validation Protocol

A description of the structured questionnaire was developed in English and translated into Amharic. A comparison of the translated questionnaires was made after translating the Amharic version of the questionnaire back to English. Different personnel checked the two versions for consistency.

The questionnaire was revised for the flow of questions and for questions that were too difficult, ambiguous and if there was any cultural sensitivity in relation to specific questions.

In the pre-testing, the investigator also tried to make out the response categories to capture all options and the questions being interpreted in the same way by different respondents too. This reconsideration assures the validity of the data what the instrument is supposed to measure.

4.6. Data Collection

Data were collected during January to February 2006. Ten data collectors, who were native speakers and had similar experience were employed and trained by the principal investigator and a Pediatrician for two days extensively in

interviewing techniques, data recording, and approaches to promote health education, and child health screening.

Photo 1: Data collector in field survey

The field supervisors accompanied the interviewers unannounced in approximately 5% of the households, and there was overlap of interviewers in approximately 5 % of the household to minimize interviewer bias. The houses were re-visited when nobody was home and by the time the questionnaire was found incomplete.

Appropriate person was contacted and provided with an overview of the survey, the importance of their response in the study in general.

Child Health Screening

After obtaining an informed consent from the head of the household and the caretaker, interview was made to the child's primary caretaker. For each child under age of five, the caretaker was asked if the child had been ill with a cough in the two weeks preceding the survey interview. For children who had been ill with cough, the caretaker was additionally asked if the child, when ill with cough, breathe faster than usual with short and rapid breath. The research defined ARI in children according to the WHO clinical case definition.

Focus Group Discussions (FGDs)

For the study needs a range of physical, social, and economic information usually a combination of methodologies, procedures, and instruments (quantitative and qualitative study approaches) were used.

FGDs were conducted which helps to determine a thorough response. Six to nine individuals were participating in each focus group discussion. The principal investigator was the moderator and the oriented local representative was the observer. To keep the quality of the data, tape recorder and quite gathering site was used.

Photo 2: Focus group discussion with caretakers, Shebedino Woreda

4.7. Data Analysis

The questionnaire responses were entered into software called EPI INFO for data clearance and skip pattern and analyzed using Statistical package for Social Sciences (SPSS) software. To observe the overall trends in the data descriptive statistics such as frequency distributions and measure of central tendencies were calculated for dependent and independent variables; and also association and correlation between dependent and independent variables were made. To identify the knowledge, attitude and belief of caregivers on the health effect of household fuel use, the transcribed (focus group) interviews were analyzed manually.

4.8. Estimation Methodology

Considering the nature of dependent variables (sometimes referred to as outcome variables), and independent variables (sometimes referred to as predictors) the statistical analysis was made using logistic regression.

4.9. Ethical Consideration and Dissemination of Results

The study was made after a support letter had been written from Addis Ababa University, Woreda Administration Office and Kebele officials. The research output will be disseminated by preparing seminars to Hawassa University, Addis Ababa University and concerned societies and also by presenting a copy of the finding (research out put) to the respective organization.

5. RESULTS

5.1. PROFILE OF SAMPLED HOUSEHOLDS

The response rate for the sampled households was 100%, except some households did not volunteer to respond to some of the questions like income and household assets and out of which 97.8% of them were married. From the total sample, residents of 135 (33.3%) households were urban dwellers and 270 (66.7%) were rural. In the following sections, profile of the household characteristics of the sample populations is presented. Association and correlation exercises for exposure variables and ARI prevalence is presented in the second section accordingly.

5.1.1. Socio-Demographic Characteristics

Table 2 shows baseline socio-demographic characteristics of 405 households in the study area. Characteristics such as education, occupation, and family income had been seen as important variables.

Table 2 Socio-demographic characteristic of households in Shebedino Woreda, February 2006

Characteristics N = 405		Frequency	Percent
Occupation	Farming	266	65.7
	Government employment	56	13.8
	Private	65	16.0
	Others	18	4.4
	Total	**405**	**100.0**
Religion	Orthodox	71	17.5
	Catholic	10	2.5
	Protestant	294	72.6
	Muslim	19	4.7
	Others	11	2.7
	Total	**405**	**100.0**
Education	12+	26	6.4
	9 - 12	72	17.8
	1 - 8	186	45.9
	Read and write	57	14.1
	Can't read and write	64	15.8
	Total	**405**	**100.0**
Annual Income (Br)	< 1200	152	39.28
	1200 - 3600	153	39.54
	3600 - 7200	61	15.76
	7200 - 10800	17	4.39
	10800 +	4	1.03
	Total	**387**	**100**
Ethnicity	Sidama	300	74.1
	Amhara	50	12.3
	Guragie	15	3.7
	Oromo	1	0.2
	Others	39	9.6
	Total	**405**	**100.0**

Sex distribution for head of the sample households was 96.8% and 3.2% for males and females respectively. The income means for 266 (65.7%) households were farming and for the rest households were private (16.0%) and government employment (13.8%).

Regarding the income, 39.54% (153) of the households were earning 1200 – 3600 birr annually and 39.28% of the households were earning less than 1200. Out of the survey households 21.18% of the households were having an income greater than 3600 Birr per year. On the other hand, the religion of the majority (72.6%) and 17.5% of the sample household heads were protestant and Orthodox respectively, and the remaining were Catholic (2.5%) and Muslim (4.7%).

The majority (45.9%) of the villagers in the samples had less than eight years of schooling as the highest education level. About 74.1 percent of head of the households were Sidama and 12 % were Amhara, moreover, Guragie and Oromo were 3.70 and 0.20 percent respectively.

About **76.5% (310) and 54.1%, (219)** of the sample households have an asset of livestock and radio respectively and television was found in 10.1% of the households (Table 3). In terms of cigarette smoking in the household, an important confounding factor in the health impacts of fuel smoke, it was learned from the interview that the prevalence of smoking more than one

cigarette per day was 6.7%. From the total sample households 29.6% had electricity and the rest 70.4%did not have.

Table 3 Household assets of 405 sample households in Shebedino Woreda, February 2006

Assets		Frequency	Percent
Livestock	Yes	310	76.5
	No	95	23.5
	Total	**405**	**100.0**
Bicycle	Yes	41	10.1
	No	364	89.9
	Total	**405**	**100.0**
Motorcycle	Yes	8	2.0
	No	397	98.0
	Total	**405**	**100.0**
Radio	Yes	219	54.1
	No	186	45.9
	Total	**405**	**100.0**
Television	Yes	41	10.1
	No	364	89.9
	Total	**405**	**100.0**
Electricity	Yes	120	29.6
	No	285	70.4
	Total	**405**	**100**

5.1.2. Housing and Kitchen Characteristics

The housing characteristics in the majority of the households were remarkably similar. About 95.6 percent of the households in the samples had walls made of thatch or wood (low quality material).

Photo 3: Characteristics of household, Shebedino Woreda

Separate kitchen was generally uncommon which was only in 29.1 percent of the sample households, otherwise in 287 (70.9%) households the kitchens were found attached/in the living house. As it is shown in Table 4, more than half of the households (55.6%) had indoor kitchens without partition walls. Adequate doors and windows were found in 8% of the sample households; however, 72.8% of kitchens were in poor ventilation.

Table 4 Housing and Kitchen Characteristics of households in Shebedino Woreda, February 2006

Characteristics		Frequency	Percent
Wall of the house	Low-quality materials	387	95.6
	High-quality materials	4	1.0
	Both low- and high-quality materials	5	1.2
	Others	9	2.2
	Total	**405**	**100.0**
Presence of separate kitchen	Yes	118	29.1
	No	287	70.9
	Total	**405**	**100.0**
Characteristics of Kitchen	Indoor kitchen without partition	225	55.6
	Indoor kitchen with partition	26	6.4
	Separate indoor kitchen outside the house	118	29.1
	Open air kitchen [outside the house]	36	8.9
	Total	**405**	**100.0**
Kitchen Wall Material	Grass, leaves, thatch	375	92.6
	Wood and mud	2	.5
	Cement, stone, brick	18	4.4
	Not stated	10	2.4
	Total	**405**	**100.0**
Kitchen Ventilation	Poor	289	72.8
	Moderate	76	19.2
	Good	32	8.0
	Total	**397**	**100**

5.1.3. Fuel-use Pattern and Stove Type

Questions on fuel-use pattern revealed that the majority of the households used wood for cooking (97.3 %) and use of crop residue was also seen in six households (Table 5). Moreover, wood was the source for boiling water and indoor heating during cold seasons.

Photo 4: Stove type used in Shebedino Woreda

The stated fuel type is obtained by purchase (59.5%) and collection/gathering (37%). About 384 households were found to be traditional stove users - cooking on three stones (Table 5). As depicted in Figure 1, chimney was found only in 30 (7.8%) households of the traditional stove users.

Table 5 Fuel Use Pattern and stove type of Households in Shebedino Woreda, Feb 2006

Fuel Use Pattern		Frequency	Percent
Fuel for Cooking	Wood	394	97.3
	Crop residue	6	1.5
	Dung Cake	2	0.5
	Charcoal	3	0.7
	Total	**405**	**100.0**
Fuel used for indoor heating	Wood	286	70.6
	Crop residue	15	3.7
	Charcoal	101	24.9
	Others	1	0.2
	Total	**403**	**99.5**
Energy source of lighting	Electricity	150	37.0
	' Masho'	1	0.2
	Candle	4	1.0
	' Kuraz'	235	58.0
	Wood	13	3.2
	' Fanos'	1	0.2
	Total	**404**	**99.8**
Fuel acquired	Purchase	241	59.5
	Collection	150	37.0
	Others	4	1.0
	Total	**395**	**97.5**
Stove Type	Traditional biomass stove	384	94.8
	Improved biomass stove	5	1.2
	Others	16	4.0
	Total	**405**	**100.0**

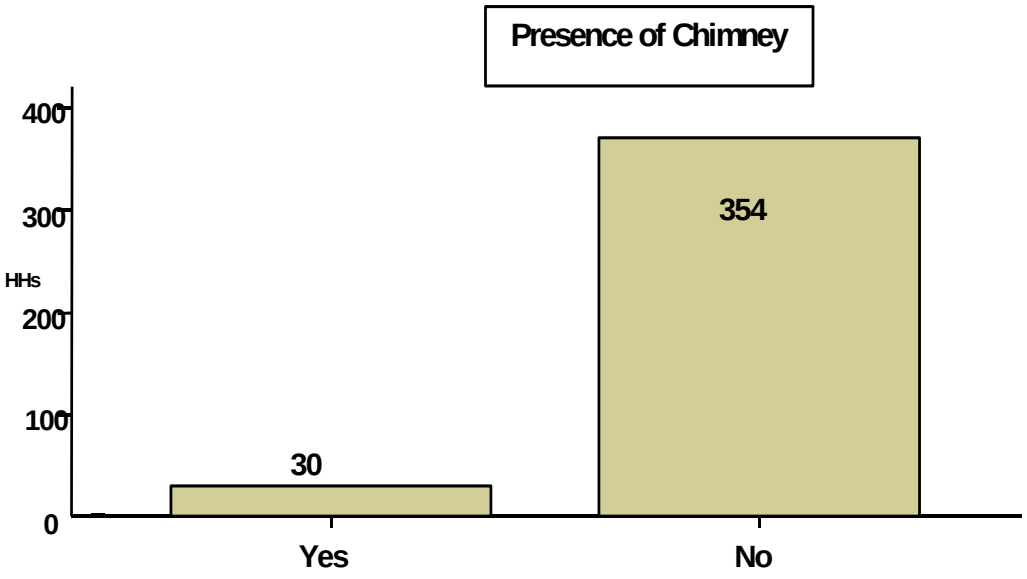


Fig. 1 Presence of chimney in the households, Shebedino Woreda, February 2006

5.1.4. Knowledge Attitude and Practice of Caretakers

As it is shown in Table 6, more than half (59.5%) of the respondents know the health effects of fuel use. Among the total sample households 53.6% of the respondents were not comfortable with the kind of stove they have for health, efficiency and stove design reason. According to the responses, over three quarter (75.8%) of the children were kept to stay indoor during the day time.

Table 6 Knowledge of caretakers regarding the heath effect of household fuel use to younger children, February 2006

Measures for KAP		Frequency	Percent
Do you know the health effect of household fuel use?	Yes	241	59.5
	No	160	39.5
	Total	**401**	**99.0**
Comfort with the kind of stove using	Yes	182	44.9
	No	217	53.6
	Total	**399**	**98.5**
Children reside during day time	Indoor	307	75.8
	Out door	94	23.2
	House of relatives	1	0.25
	Others	3	0.75
	Total	**405**	**100.0**

Result From Focus Group Discussion

To supplement the quantitative information regarding the knowledge and attitude on the associated health impact of household fuel use on younger children group discussion was made with caretakers/mothers.

A total of 8 focus group discussions were made where 35 mothers of under-five children participated. The participants were not literate and they were in the age of 30 to 55.

The following responses were classified accordingly to the topic guide/questions under study.

Topic 1

Do you have the knowledge about the health impact of household fuel use?

- All responded with a feeling that the concept of the health impact is well perceived
- Few participants put some specific area to be affected due to exposure, like, eye, respiratory system, and mental effects

Topic 2

In your opinion, what fuel and stove types will have more impact?

- Majority of the participants articulated that cow dung and straw would affect their health.
- Few participants were not aware of the impact with stove type

There were participants who highlighted finance for not having energy efficient and clean stoves even though they know the impact because of fuel and stove type.

Heated discussion was made on the financial issue and the following point was given more emphasis by few participants:

"We know that even the cost for getting medical treatment is more compared to cost for the stoves in the market. But we usually care for the daily need, i.e. food and others."

For the reason they provide less concern on the subject of stove and fuel type they were asked how they take care of the child while cooking. Few participants stated that they keep the child covered with a cloth while cooking. Moreover, one mother highlighted the following point:

"I do not feel that it has serious impact. When the child comes to see me, I would not let him out rather I let him stay on the ground, keep watching."

Regarding the kitchen and house design (in terms of having windows), all participants made similar statement.

"We did it once with no knowledge; we do not have the explanation even to notice its health importance."

Furthermore, at the middle and end of the discussions, few participants made some remarks.

" It would be better if we could be organized to look for solutions, in terms of financial, and getting the skill for making the stove locally and simple modification of the house for a better ventilation."

One participant from one group said, "Had the training been given to our husbands it would acquire attention for better solution. It is mainly because we always depend on what they are concerned."

5.1.5. Prevalence of Acute Respiratory Infection (ARI)

The prevalence for acute respiratory infection (defined as of presence of cough with or without fever) for the two weeks prior to the interview was 21.0% (Table 7). Among the children with the sign of cough, 42.35% had trouble breathing (breath faster than usual with short, fast breaths-which is the symptom for pneumonia).

Table 7. Distribution of ARI prevalence of younger children in Shebedino Woreda, Feb 2006

Screening		Frequency	Percent
ARI	Yes	85	21.0
	No	320	79.0
	Total	**405**	**100.0**
Pneumonia	Yes	36	42.35
	No	47	55.30
	Do not know	2	2.35
	Total	**85**	**100.0**

5.2. QUANTIFYING STRENGTH OF ASSOCIATIONS BETWEEN VARIABLES

To quantify the degree of association and determine its significance the following statistical tests were made with compliance to the variables under study.

I. Chi-square

Chi Square was used for nominal data for determining the presence of an association between two qualitative variables. Rejection of the null hypothesis, however, only establishes the existence of a statistical association but it does not measure its strength [38].

II. Spearman's rho

For ordinal data Spearman rank correlation was used, which is quite satisfactory for testing the null hypothesis of no relationship, but is difficult to interpret as a measurement of the strength of the relationship [39].

III. Pearson correlation

The Pearson correlation was used to measure a supposed association between quantitative variables**.**

IV. Logistic regression model

Logistic regression was used for the overall modeling exercise for the reason that the outcome variable is dichotomous (ARI case). This statistical test is required to predict the proportion of individuals who have the characteristic, or estimate the probability that an individual will have the symptom.

Association and Correlation Exercises

According to the study, there was no sufficient evidence for the significant association of ARI prevalence with educational status of head of the households, residence, means of income, number of rooms, stove type, and kitchen features (Table 8).

Table 8 Distribution of the general characteristics of the sample households and reported ARI prevalence among younger children in Shebedino Woreda, February 2006

Characteristics		ARI		P-Value [95% C.I.]
		Yes	No	
Residence	Urban	24	111	P > 0.05
	Rural	61	209	
	Total	**85**	**320**	
Asset (Radio)	Yes	42	177	P > 0.05
	No	43	143	
	Total	**85**	**320**	
Asset (Television)	Yes	4	37	P < 0.05
	No	81	283	
	Total	**85**	**320**	
Education	12+	3	23	P > 0.05
	9 - 12	14	58	
	1 - 8	37	149	
	Read and write	13	44	
	Can't read and write	18	46	
	Total	**85**	**320**	
Means of Income	Farming	55	211	P > 0.05
	Government Employment	8	48	
	Private	19	46	
	Others	3	15	
	Total	**85**	**320**	
Kitchen	Indoor without partition	56	169	P < 0.05
	Indoor with partition	4	22	
	Separate with superstructure	19	99	
	Open air kitchen	6	30	
	Total	**85**	**320**	
Fuel Acquired	Purchase	40	201	P < 0.05
	Collection	38	112	
	Total	**78**	**313**	
Stove Type	Traditional biomass stove	82	302	P > 0.05
	Improved biomass stove	1	4	
	Others	2	14	
	Total	**85**	**320**	
Chimney	Present	2	28	P < 0.05
	Absent	83	287	
	Total	**85**	**315**	
Soot in the house	Present	60	183	P < 0.05
	Absent	25	134	
	Total	**85**	**317**	

Children living in the house that was not separated from the kitchen, were considerably high likely to have had ARI than those from households having separate kitchen. Similarly, children were highly likely to have had ARI in the households where there was no chimney in the kitchen.

Variables like, kitchen characteristics, presence of television and chimney attached to the stove, presence of soot on top of the wall and roof of the houses were associated with prevalence of ARI at 95% C.I.

There is no sufficient evidence to associate the prevalence of ARI among younger children with the presence of an asset [radio], educational status of head of the household, means of income, residence, and stove type of the sampled households.

Table 9 Pearson's Correlations for time spent by children and caretakers close to cooking stove

		Time spent by caretaker	Time spent by child
Time spent by caretaker	Pearson Correlation	1	-.246
	Sig. (2-tailed)		0.000
	N	398	373
Time spent by child	Pearson Correlation	-.246	1
	Sig. (2-tailed)	0.000	.
	N	373	373

Correlation is significant at the 0.01 level (2-tailed).

The average cooking time per day of the households was 6.69 hour. On the other hand, the average time a caregiver and the children in the room were 354

minutes (5 hrs and 54 minutes.) and 110 minutes (1 hour and 50 minutes) respectively (Figure 2). The overall analysis of the amount of time a child spent in the burning room within 1.5-meter distance from the cooking stove was negatively correlated with the amount of time a caregiver spent in the burning room. But as shown in figure 2 there is discrepancy in the correlation for various time pattern (Pearson's r = - 0.246; p < 0.01).

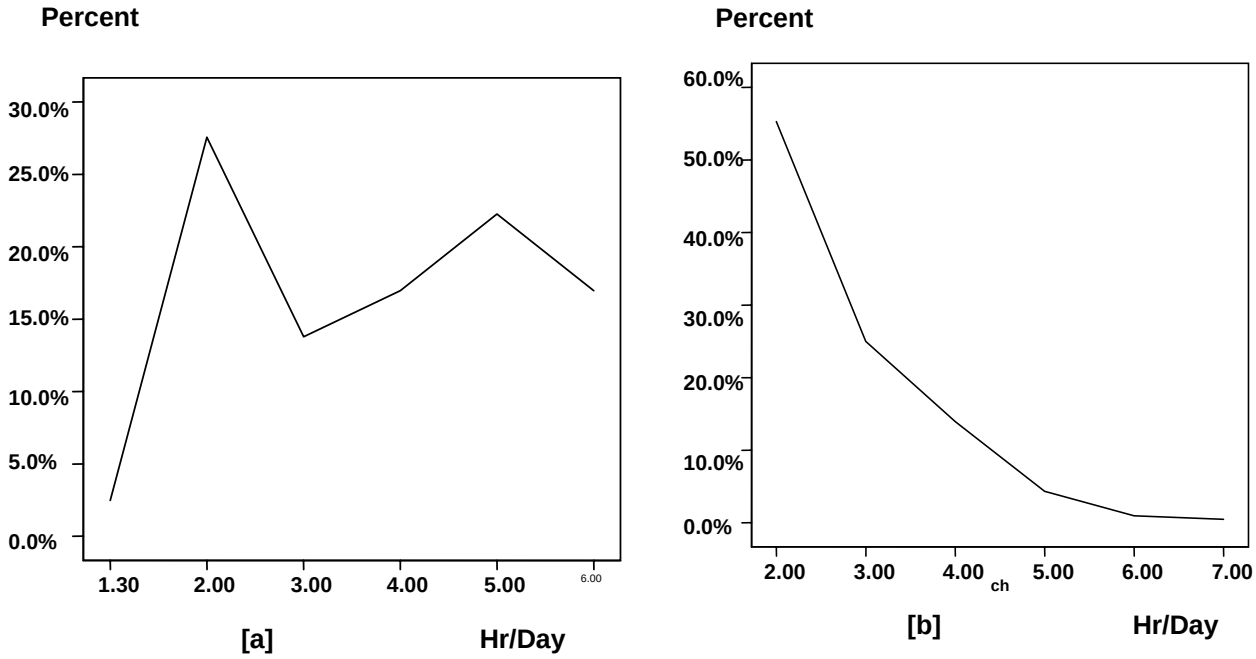


Fig 2 Time spent in the kitchen (within 1.5 meter distance from the stove) per day in hour

Table 10 Spearman's rank correlation (rho) matrix for ordinal explanatory variables

[rho]	Poverty Line	Kitchen Ventilation	Window Size	Education [HHH®]	Stove Type	Kitchen Character
Povertyline	1.000	.162(**)	-.038	-.134	.065	.168(**)
KitchVentl	.162(**)	1.000	.708(**)	-.245(**)	-.008	.307(**)
Windsize	-.038	0.708	1.000	-.207(*)	.	.382(**)
Education	-.134	-.245(**)	-.207(*)	1.000	-.015	-.304(**)
Stovtype	.065	-.008	.	-.015	1.000	.051
Kitchchara	.168(**)	.307	.382(**)	-.304(**)	.051	1.000

**** Correlation is significant at 0.01 level (2-tailed).**

***** Correlation is significant at 0.05 level (2-tailed).**

As depicted in Table 10, the spearman's correlation matrix for the explanatory variables in which case the poverty line was correlated with characteristic of the kitchen and kitchen ventilation at 0.01 level of significance. Similarly, educational status of head of households was correlated with characteristic and ventilation of the kitchen at 0.01 level of significance, but with the size of windows at 0.05 level of significance.

® Head of the Household

Modeling Exposure Variables

Results of the exposure variables were used together to develop model to predict ARI prevalence among younger children. Because our response variable- Prevalence of ARI- is dichotomous, logistic regression was used to estimate the effect of household energy use on ARI prevalence in the two weeks preceding the survey. In developing the model, identification of exposure variables (explanatory variables) that were significantly associated with ARI prevalence was made.

One variable (amount of fuel use) was omitted from the analysis, as it was not possible to estimate accurate measurements across all households.

Table 11 Child handling practice and ARI prevalence among younger children in Shebedino Woreda, February 2006

			Carrying the Child on the Back of the Caretaker		**Total**
			Yes	No	
ARI	Yes	No.	59 (43.7)♣	26 (41.3)	85
		% of Total	14.6%	6.4%	21.0%
	No	No.	149 (164.3)	171 (155.7)	320
		% of Total	36.8%	42.2%	79.0%
Total		No.	208	197	405
		Percent	51.4%	48.6%	100.0%

♣( ) Expected Count

In the modeling exercise it was difficult to make category classification for some data like fuel type, housing characteristics as they become constant. As a result of this approach and specifications, one variable—the way children are kept while cooking—was found to be useful to the model and which is good predictor of the ARI prevalence (at 0.05 level of significance). As it can be shown in Table 12 the 95% confidence interval for the odds ratio is (0.221, 0.647).

Table 12 Variables in the Equation-predictor of ARI prevalence

	B	S.E.	Wald	df	Sig.	Exp(B)	95.0% C.I. for EXP(B)	
							Lower	Upper
	-.973	.274	12.588	1	.000	.378	.221	.647
Constant	1.875	.224	70.120	1	.000	6.522		

Exp (B) – is the odds ratio. Mathematically, this is e (the base of the natual logarithm, 2.718) raised to the power of B. In this exercise, 2.718 raised to the power of -0.973 is 0.378.

6. DISCUSSION

The intent of this research was to assess the health risk of Household Fuel Use to younger children and to evaluate factors that modulate exposure to indoor air pollution from this household fuel use.

ARI prevalence of the study area (21%) was found to be lower as compared to the national figure (24%) in 2000 [40]. Strict use of the case definition on the combinations of symptoms and the skill of the data collectors may be one reason for the discrepancy. However, it is amazingly too high compared to a one-year community study of under-fives in Butajira [41] – where the prevalence was 2.8%. It is partly explained that factors like, the household set up, socio economic characteristics, residence, distribution of children by age and sex and time of study undertaken may contribute for the inconsistency.

According to spearman's correlation matrix for the explanatory variables, the poverty line was correlated with characteristic of the kitchen and kitchen ventilation. Moreover, educational status of head of households was correlated with characteristic and ventilation of the kitchen (Figure 3 and 4).

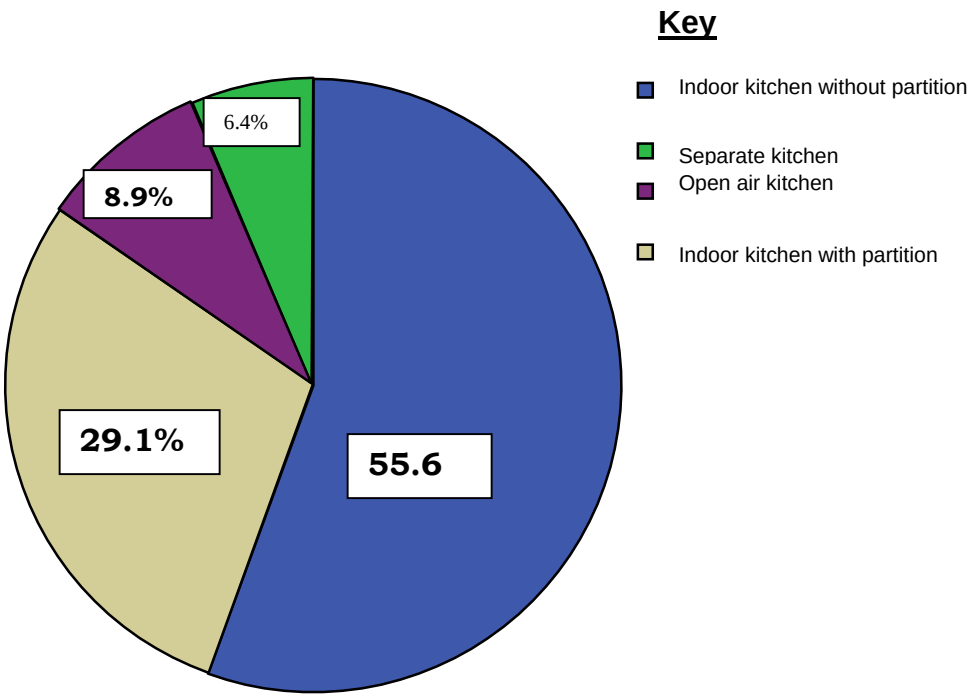


Fig 3 Characteristics of Kitchen in the sampled households, Shebedino Woreda, Feb 2006

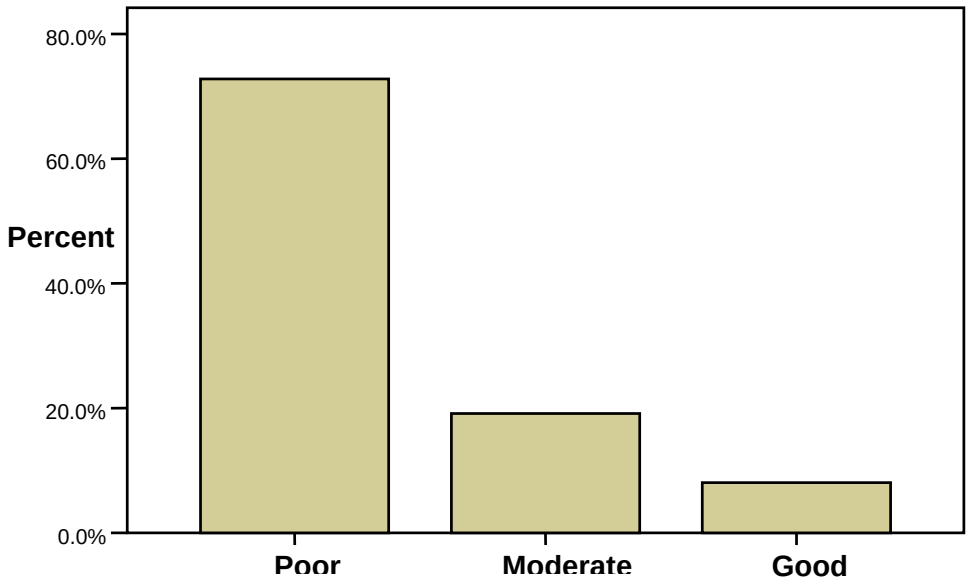


Fig 4 ventilation condition of kitchens in the sampled households, Shebedino Woreda, Feb 2006

The result revealed that combustion of solid fuels in unventilated indoor areas and at low thermodynamic efficiency might lead to high concentrations of smoke and other pollutants and this was expected to happen in houses where mothers have primary or no education.

From this study, conversely, there was no sufficient evidence for the significant association of ARI prevalence with educational status of head of the household. Further analysis also shows that there was no sufficient evidence for the significant association of ARI prevalence with residence, means of income, number of rooms, stove type, and kitchen features. These findings are contrary to the existing literatures and expected results.

However such unexpected findings may occur in cases where a considerable number of mothers with primary or no education may forget previous episodes of ARI among their children for they do not have medical or any other form of records. Likewise, educated mothers who are employed and therefore have to find maids to look after their children may be a factor for under estimation of ARI. In most cases these maids have primary or no education and this may have the same effect as mothers who have primary or no education.

Evidences indicate that, the amount of time a child spent in the burning room within 1.5-meter distance from the cooking stove was negatively correlated with the amount of time a caregiver spent in the burning room (Pearson's r = -

0.246; $p < 0.01$). Among the total sample households, more than half (59.5%) of the respondents know the health effects of fuel use and 53.6% of the respondents were not comfortable with the kind of stove they have for health, efficiency and stove design reason. However according to the responses, over three quarter (75.8%) of the children were kept to stay indoor during the day time.

Result from the focus group discussion also revealed that most participants dad the concept of the health impact due household fuel use and they also articulated that cow dung and straw would affect their health seriously. Moreover, few participants were not aware of the impact with stove type.

On the contrary regarding the knowledge about the impact because of fuel and stove type participants stated that they keep the child covered with a cloth while cooking. This has an indication for the mothers have a gap of knowledge that the small particles from burning could enter deep into the lung and respiratory organ.

This indicates that the caretaker (usually the mother) behavior to the health risk of fuel use give the impression of consistency with the child spending time in the burning room. But the discrepancy in the response is likely because of respondents might feel that they will be socially dishonored.

More importantly, Figure 5 shows the box plots of the length of time children with the case ARI reside indoor during burning. From the figure the distribution of length of time for children, with ARI case, is much more symmetrical than that of children with no case.

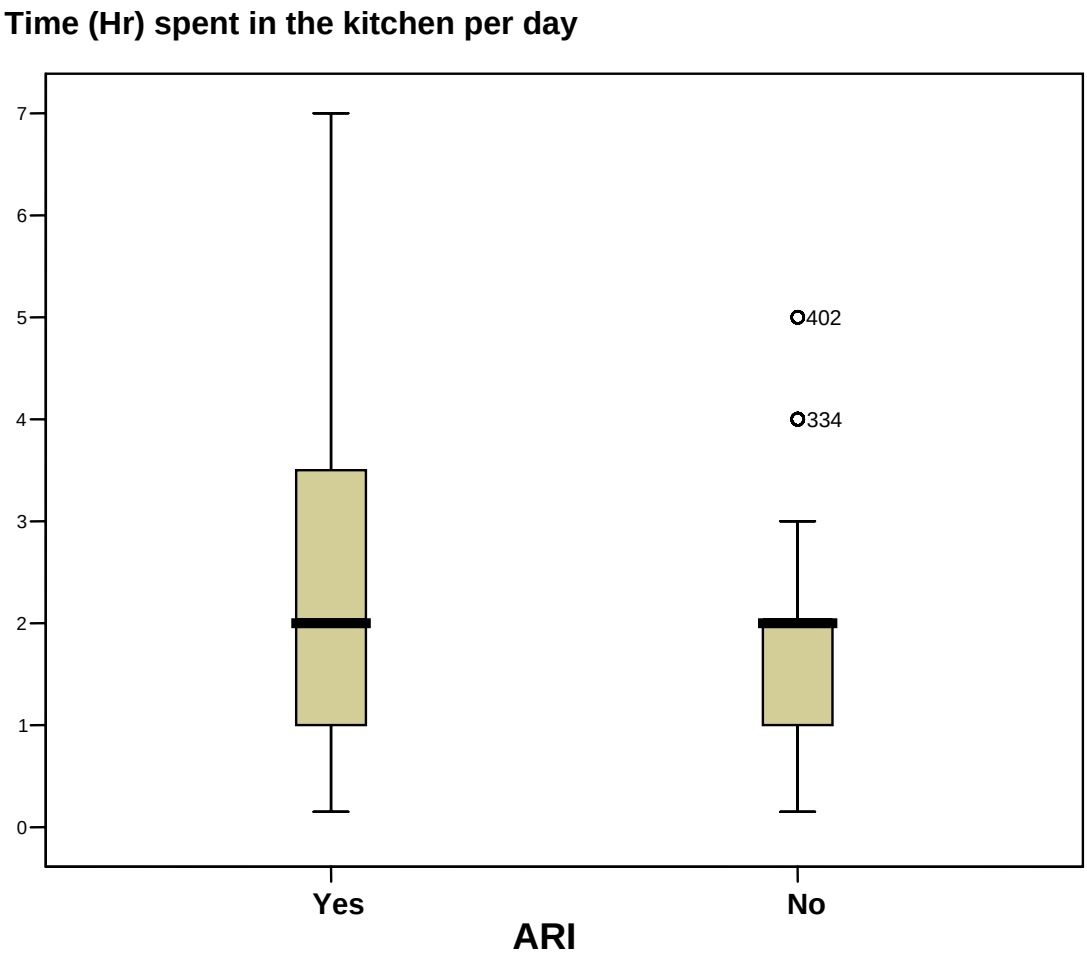


Fig. 5 ARI Status and Length of time the child resides indoor during burning

According to the study, over three-quarter (75.8%) of the children were kept to stay indoor during the daytime. This will draw attention to the risk of child often in the confined house and to the need for further research on other possible health impact due to the indoor environmental burden to the younger

children. A recent report of the World Health Organization (WHO) asserts the rule of 1000 which states that a pollutant released indoors is one thousand times more likely to reach people's lung than a pollutant released outdoors (25).

Alternately, children living in the house that is not separated from the kitchen were considerably more likely to have had ARI than those from households having separate kitchen. Similarly, children were highly likely to have had ARI in the households where there was no chimney in the kitchen. Although the evidence regarding behavior and practice of child handling while cooking was a factor for ARI prevalence, it might be for the reason that the children would be exposed less in the houses. Moreover there is a possibility for children to be exposed to pollutants even not in the cooking time provided that the stove is indoor.

Presence of television was associated with prevalence of ARI. It is more likely that people can get the health information using medias. An asset of television mainly for the households having electricity where they might use as household energy source and also children are likely to spend watching television in the house that is separated from the kitchen too.

Variables like, kitchen characteristics, presence of soot on top of the wall and roof of the houses were associated with prevalence of ARI [$p<0.05$]. The presence of soot on the top of the wall is one indicator for the pollutant burden

in the households. As a result, high ARI prevalence is expected in households where soot was present. Moreover, it is likely that kitchen characteristic and presence of chimney attached to the stoves to be associated with prevalence of ARI.

The logistic regression analysis shows that the way children were kept while cooking was found to be good predictor of ARI prevalence independent of tobacco smoke, child's age and nutritional status(OR = 0.387; 95% C.I: 0.221, 0.647). However According to many findings stove type, residence, and sex of the child were good predictors of prevalence of ARI [42].

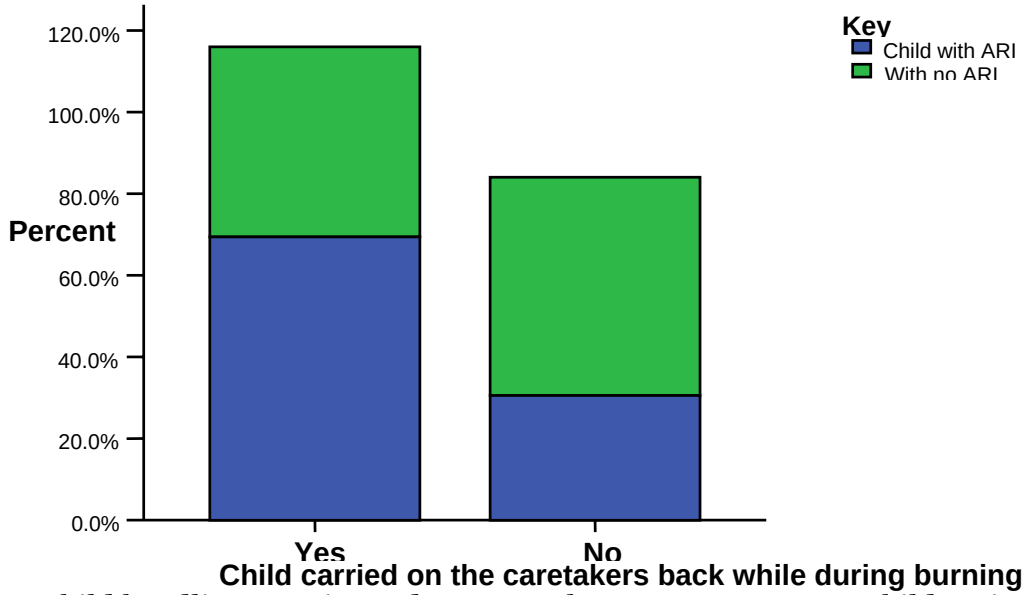


Fig 6. Child handling practice and ARI prevalence among younger children in Shebedino Woreda, Feb 2006

This gives the explanation that children, who were isolated from the mother while cooking were taking place, were less likely of contracting ARI compared to those carried on the mothers back (or keeping isolated reduced the risk of ARI by 62.2%). This data is consistent with WHO estimation for global ARI burden associated with indoor air pollution and other environmental factors.

Study Strengths

- The participation rate for the survey was high
- It is less expensive and time consuming
- The research is focused on younger children because children in this age group do not attend school, and they are likely to spend more time indoor with their mothers or caretakers.

Study Limitations

- Comparison groups in terms of different stove type users were not studied and information about other factors to ARI were not collected.
- The research method is limited for an in-depth understanding of the potential for child health risks [risk characterization]

7. CONCLUSIONS

Obviously no nation can aspire to develop economically without paying due attention to its energy consumption and supply patterns. The existing environmental and socioeconomic factor in the study area has a considerable potential to contribute for environmental threats to the health of children. It will be no surprise that exposure to particulate matter can be high in rural indoor areas.

The study approach appears to demonstrate a relatively consistent association between child handling practice while cooking and childhood ARI. The research results also suggest further analysis in the link between income and exposure variables.

Policy Implication and Areas of Further Researches

Biomass will remain, for many years, the principal cooking fuel for a large majority of rural households in Ethiopia. Hence, it requires an effective strategy for improving fuels and cooking technologies, housing improvements, kitchen environment and design. The health cost imposed on economy due to solid fuel use is enormous, so concerned health sectors should lobby for alternative policies.

An obvious implication is that educating the public about the adverse effects of cooking smoke on child health and on good child handling practice through community participation is essential.

It gives the idea of research/policy demand for risk characterization - an in-depth understanding of the potential for child health risks in terms of exposure potentials, especially crucial for vulnerable poor communities.

Even though the research did not include comparative analysis of the stove types with the outcome of the disease, it is obvious that strength should be made on stoves that use fuel more efficiently and produce less smoke than traditional models.

8. Reference

1. National Academy Press, *Energy Survey Methodologies for Developing Countries*, Washington, D.C. 1980.
2. Smith K, Samet J, Romieu I, Bruce N. Indoor air pollution in developing countries and acute respiratory infections in children, 55: 518-532, 2000.
3. Bruce N, and et'al; Indoor pollution in developing countries: a major environmental and public health challenge. *Bulletin of the WHO;* 78:1078-1092, 2000.
4. World Energy Council*; The Challenge Of Rural Energy Poverty In Developing Countries; 1999-2005,* London, 2005.
5. The World Resources Institute, World Resources*: A Guide to the Global Environment,* Oxford University Press, 1998.
6. Fact sheet N°292*, Indoor air pollution and health,* June 2005.
7. WHO; *The World Health Report 2001,* Geneva, World health organization, 2001.
8. WHO*; Indoor Smoke from Solid Fuels; Assessing the Environmental Burden of Disease at national and Local Levels;* Series No. 4; 2004.
9. WHO (World Health Organization) *The world health report 1995: Bridging the gaps.* Geneva: World Health Organization, 1995.
10. Douglas, R. and E. Kerby-Eaton (editors). *Acute respiratory infections in childhood. Proceedings of International Workshop,* Sydney, University of

Adelaide, 1985.

11. Focus on Ethiopia*, United Nations Office for Coordination of Humanitarian Affairs in Ethiopia;* September 2003.

12. Majid E and Daniel M. Household Energy, Indoor Air Pollution, And Health In Developing Countries*: Annual Review of Energy and the Environment,* Vol. 27: 233-270, 2002

13. Ethiopian Energy Authority, Ministry of Mine and Energy, Ethiopian Energy Statistics 1985/86-1989/90, 1991.

14. Murray, C. J. L., and A. D. Lopez, Eds. *The global burden of disease. Cambridge,* Massachusetts: Harvard University Press, 1996.

15. World Energy Council*; Energy for tomorrow's world – the realities, real options and the agenda for achievement.* London, 1993.

16. Bruce N and et'al; Indoor air pollution in developing countries: a major environmental and public health challenge. *Bulletin of the world health organization;* 78(9): 1067-1071; 2000.

17. Smith K. and et'al Indoor air pollution in developing countries: *Recommendations for research. Indoor Air,* 12:198-207, 2002.

18. Kara A. and et'al; *Overview of the special Vulnerability and Health problems of Children, Paper series on Children's Health and the Environmental;* February, 2003.

19. David G.; Children in their environment: vulnerable, valuable and at risk, *Third Ministerial Conference;* June 1999.

20. Household Energy Use in Developing Countries*: A Multicountry Study* October 2003.

21. World Health Organization, Health and Environment in Sustainable Development: *Five Years after the Earth Summit,* WHO, Geneva, 1997.

22. Pryde B. and Philip. R.; *Non conventional energy resources,* New York: John Wiley and Sons, Inc.; 1983.

23. NEIPTG. Criteria Air Contaminants Emissions Inventory Guidebook. *National Emissions Inventory and Projections Task Group.* Canadian Council of Ministers of the Environment; 2000.

24. Smith K. and et'al;. *Indoor air pollution in developing countries and acute lower respiratory infections in children.* 55:518-532, 2000.

25. World Health Organization, Health and Environment in Sustainable Development: *Five Years after the Earth Summit,* WHO, Geneva, 1997.

26. GTZ, *Household energy program,* 1997.

27. WHO [World Health Organization], World Health Report 1999 Database*: http:/www.who.int/violence_injury_prevention/injury/InjuryBofDtables.htm:* [Date accessed January 2006].

28. Bruce. N., Household energy & health: *The knowledge network on sustainable household energy in Southern and Eastern Africa,* 2002.

29. Armstrong J., and Campbell H; *Indoor air pollution and lower respiratory infections in young Gambian children.* Int J Epidemiol 20(2): 424-, 1991

30. Nigel B; Household Energy and Public Health: *an introduction,* United Kingdom; 2002.

31. Brendon R. Barnes, "Interventions to reduce child exposure to Indoor air pollution in Developing countries: *Behavioural opportunities and research needs," children, Youth and Environments* 15(1): 67-82, 2005.

32. Miller, NEHA, *Indoor Air Quality assessment of Daycare facilities with Carbon Dioxide, Temperature, and Humidity as Indicators:* 65: 4, 2002.

33. WHO; child health in the community *"Community IMCI" briefing package for facilitators,* 2004.

34. Smith K., The National Burden of disease in India from indoor air pollution. *Proceeding of the National Academy of Sciences (USA),* 97: 2000.

35. Smith, K. and et'al; M. Indoor smoke from household solid fuels. In: Ezzati M, Rodgers AD, Lopez AD, Murray CJL (eds) *Comparative quantification of health risks: Global and regional burden of disease due to selected major risk factors,* Geneva: World Health Organization, Vol 2. 2004.

36. United Nations, Report of the Secretary General on We the Children: *End-Decade Review of Follow-up to the World Summit for Children,* New York, 2001.

37. Negassa S. *Rapid Health, Nutrition and Food Security Assessment of Shebedino Woreda,* Sidama, SNNPR, Ethiopia, April, 2005.

38. Altman DG; *Statistics and Ethics in Medical Research,* British Medical association, London, 1982.

39. Martin B, *An Introduction to Medical Statistics,* 3rd Ed; Oxford University Press, 2000.

40. Central Statistics Authority [Ethiopia] and ORC Macro, Ethiopian Demographic and Health Survey 2005: *Preliminary Report,* 2005.

41. Muhe L, and et'al; a one-year community study of under-fives in rural Ethiopia: *patterns of morbidity and public health risk factors.* Public Health; 109(2): 99-109, 1995.

42. Ambrose S., *Relationship between indoor air pollution and acute respiratory infection among children in Uganda,* January 2005.

ANNEX II

QUESTIONNAIRE- Survey Instrument

ADDIS ABABA UNIVERSITY
ENVIRONMENTAL SCIENCE PROGRAM

HOUSEHOLD FUEL USE A THREAT TO THE HEALTH OF YOUNGER CHILDREN IN SHEBEDINO WOREDA

Introduction to Interview

Hello, I am _____ from _____. The purpose of my presence here is to collect research data that help to evaluate the health impact of solid fuel use on younger children in this area.

I would like to ask you some questions about your household. This information will help people plan programs to decrease health risk of children in homes. It will take about 40 minutes. Participation in this survey is voluntary. You can choose not to answer any question. If you decide to participate, you may stop answering questions at anytime. All information will be kept strictly confidential and will not be shown to other persons. Do you want to ask me anything about this survey at this time?

*Signature*_____ *Date*_____

GE-1 *INTRESPON*

Response:	Respondent agrees for interview	01
	Respondent declines interview	02
Start time:	____:____ am/pm	

Although your participation is voluntary, I hope you will participate in the process of this important study.

GE-2 *RES*

Residence	Cluster No	Code	Kebele	House No.
Urban.....1				
Rural.....2				

GE-3 *YRRES* How long have you been in this area? _____

SECTION A
HOUSHOLD CHARACTERISTICS

A-1 *NPEOPLE* Including you, how many people live in this household?
Enter the number .....

A-1a1 *NU5CHILD* How many are children under the age of five?
Enter the number.....

A-1a2 *NGR5YEAR* According to the counts so far, there are _____ (remaining number of this household), all of whom are greater than five years old. Is that correct
Yes.....1
No.....2

A-2 *SEXHEAD* Sex of the household head
Male.....1
Female..... 2

A-3 *ETHNHEAD* Ethnicity of the household head
Sidama.....01
Amhara.....02
Tigre.....03
Oromo.....04
Guragie.....05
Other.....06

A-4 *RELHEAD* Religion of household head
Orthodox.....01
Protestant..... 02
Muslim..... 03
Others ..... 04, specify _____

A-5 *MARITST* Marital status
Single.....01
Married.....02
Divorce.....03
Widowed..... 04

A-6 *MEANSINCOM* Main means of income
Farming.....01 Government employee..... 02
Private employee... 03 others.....04 _____

A-7 *TOTINCOME* The total combined income for the past 12 months of all members of the households living here
Enter the No.....

A-8 *EDUHEAD* Educational level of household head

Illiterate……01
Read and write…… 02
Primary…… 03
Secondary…… 04
Tertiary…… 05

A-9 *MOTHEREDU [If* head of the household is different from the mother]
Mother's/guardian education …… [Refer the No from A-8]

A-10 *HHSTINDEX* Does the household own any of the following:

Assets	Yes	No
A-10a1 Livestock?	1	2
A-10a2 A cot/bed?	1	2
A-10a3 A clock/watch?	1	2
A-10a4 A bicycle?	1	2
A-10a5 A motorcycle?	1	2
A-10a6 A radio?	1	2
A-10a7 A television?	1	2
A-10a8 Animal cart?	1	2
A-10a9 Access to electricity?	1	2
A-10a10 Highest grade completed by any member of the household? [0 If less than 1]		
A-10a11 Dose any member of the household smoke more than 1 cigarette everyday at home?	1	2

SECTION B

HOUSING CHARACTERISTICS

B-1 *UNITHSE* Type of housing unit

Detached house……01
Attached house…… 02

B-2 *NROOMS* Number of rooms in the house

Enter the number……

B-3 *TYPEHSE* House type:

Made from mud, thatch, or other low-quality materials……..01

High-quality materials [brick, block or stone]……02

Made from both low- and high-quality materials…….. 03

B-4 *SMOKEHSE* Household where some/much smoke observed

Yes……1
No……2

B-5 *GAPRW* Gap between roof and wall

Yes……1
No……2

B-5a1 [If GAPRW is yes] GAPSIZE Record the size of the gap in centimeters

Enter the No……cm

B-6 *NDOOR* Number of doorways ……

B-7 *NWINDWS* Number of windows……

SECTION C

KITCHEN CHARACTERISTICS

C-1 *KITCHENSEPAR* Do you have a separate room that is used as a kitchen

Yes……1
No……2

C-1a1 [If yes] *PARTEXT* Does partition extend to the ceiling?

Yes……1
No……2

C-1a2 [If No] *PAREXTLEN* Record height of partition ……cms

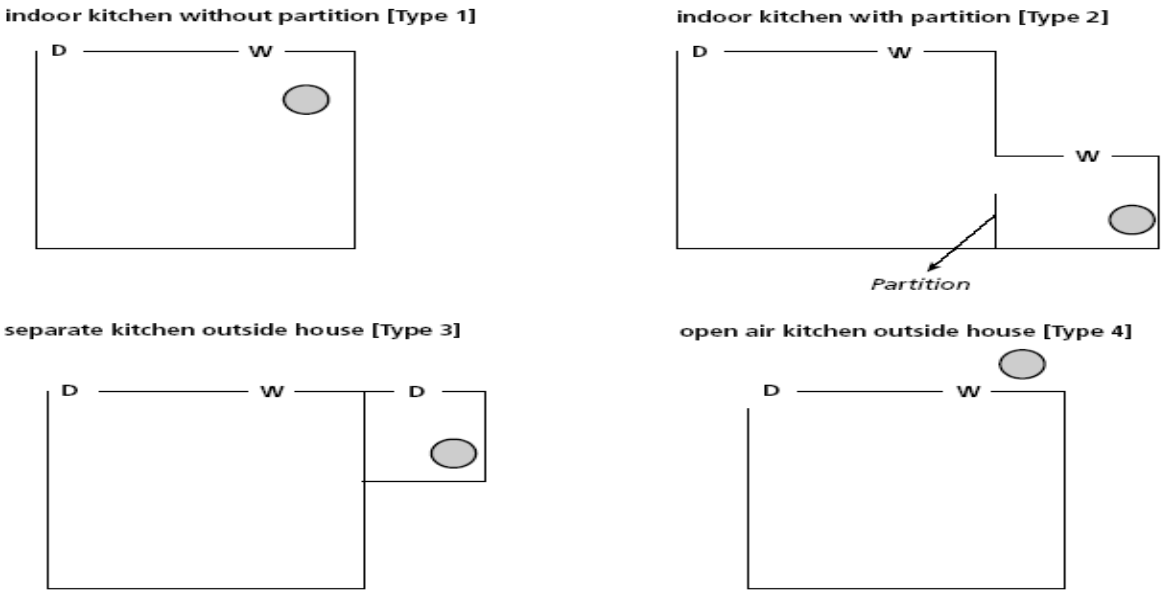
C-2 *CHARKITCH* Characteristics of the Kitchen [Refer figure 1]

Indoor kitchen without partition 01
Indoor kitchen with partition 02
Separate indoor kitchen outside the house..... 03
Open air kitchen [outside the house]..... 04

C-2a1 [If open air kitchen] *KITCHSHED* Is the stove located under any shed roof or canopy?

Yes.....1
No.....2

If yes what is this shed..... Figure 1



C-3 *KITCHROOF* Kitchen roof material

Thatched roof, grass, leaves, wood, mud..... 01
Corrugated iron sheet.....02
Brick, stone and lime..... 03
All other material not stated..... 04

C-4 *KITCHWALL* Kitchen wall material

Grass, leaves, thatch.....01
Wood and mud.....02
Brick and cement.....03
Stone and cement.....04
Other material not stated.....05

C-5 *KITCHFLOOR* Kitchen floor material

Earth……01 Cemented……03

Wood/planks……02 Not stated…… 04

C-6 *KITCHENL* Length in meter	
C-7 *KITCHENW* Width in meter	
C-8 *KITCHENH* Height in meter	
C-9 *NWINDKITCH* Number of windows in kitchen	
C-9a1 *SIZE* For each window rate size: Small: less than of A4 sheet……01 Medium: half to full size of A4 sheet…02 Large: Larger than A4 sheet…… 03	Window1…… Window2…… Window3…… Window4……
C-10 *VENTKITCHEN* Please rate the ventilation of the kitchen: Poor: a house with only one door Moderate: a house with only one door and window Good: a house more than one door and window	Poor……01 Moderate……02 Good…… 03

SECTION D

HOUSEHOLD ENERGY CONSUMPTION

D-1 *FUELCOOK* Dominant fuel used for cooking?

Wood……01 Kerosene……05

Crop residues……02 Electricity…… 06

Dung cakes ……03 Others……07

Charcoal……04

D-2 *FUELBOIL* Dominant fuel used for boiling/heating water?

Wood……01 Kerosene……05

Crop residues……02 Electricity…… 06

Dung cakes ……03 others……07

Charcoal……04

D-3 *FUELHEATINDR* What type of fuel does your household commonly use for heating indoors?

Wood……01 Kerosene……05

Crop residues……02 Electricity…… 06

Dung cakes ……03 others……07

Charcoal……04

D-4 *SOURCELIGHT* main source for lighting [Record all mentioned]

Lump (electricity)……01

Candle……02

Kerosene (Kuraz)……03

Wood burning…… 04

Others……05 Specify _____

D-5 *FUELAMNT* How much unit in amount is the fuel used per day? [kg, liters, or local measurement]

Wood…… Kerosene……

Dung cakes …… Crop residues……

Charcoal……

D-6 *FUAQUIR* How is the fuel acquired?

Collected…… 01

Purchased…… 02

D-7 *FUCOLTIM* If collected, approximately how much time you spend collecting per unit of time? [E.g. 10 min per day]

Time…… Per……

D-8 *FUPURCHTIM* If purchased, approximately how much time you spend per unit of time?

Time…… Per……

D-9 *SEASCOOKPAT* Does the household's cooking pattern change seasonally?

Yes……1
No……2
If yes, describe changes and reason for change?
……
……

D-10 *COOKAREACH* Has your household ever changed its cooking area?

Yes……1
No……2
If yes, describe changes and reason for change?
……
……

D-11 *COOKTIME* Amount of time spent cooking in a day

Enter the number ……[Hr:Min]

D-12 *HOMBASBUZ* Do you operate a home-based business or service?

Yes……1
No……2
D-12a1 [If yes] would you please tell me the kind of business

……

SECTION E

STOVE CHARACTERISTICS

Note: A stove is defined by the presence of a fire/combustion chamber. Count two fires as two stoves, even if they look alike and are side by side.

E-1 *TYPSTOV* Type of stove		Number
Traditional biomass stove……	01	……
Improved biomass stove……	02	……
Kerosene stove……	03	……
Other……04		……

E-1a1 [If traditional biomass**01**] *STOVHOOD01* Does the stove has a hood?

Yes……1
No……2
If yes describe the hood
……

E-1a2 [If Improved biomass**02**] *STOV02* For how long have you had this stove?
…… Months/year

E-1a3 [If kerosene stove**03**] *STOV03* When is the stove used?

For cooking……01
When making tea……02
When boiling water……03
Rainy days……04
During shortage of other fuel……05
Other……06 specify……

SECTION F
HOUSEHOLD ENERGY RELATED KNOWLEDGE

F-1 *ATTHIMPI* Do you know the health impact of fuel use?

Yes……1
No……2

F-2 *ATTAGERSK* Which [age group] do you think at high risk?

< 5 years……01
5-15 years……02
Elders……03

F-2a1 [If 01] *ATTAGERSK01WHY* why are they at risk?

……

F-3 *ATTSTOV* Are you comfortable with the kind of stove you are using?

Yes……1
No……2

F-3a1 [If yes] *ATTSTOV1WHY* Why?
……

F-3a2 [If No] *ATTSTOV2SOLU* Have you ever did any modification to find solution for your fuel use?

Yes……1
No……2

F-3a21 [If yes] what and how?

……

……

F-3a22 [If No) *ATTSTOV2SOLU2WHY* Why?

Financial problem……01

Knowledge/skill……02

Time……03

Others……04, Specify……

F-4 *STOVOPT* Do you know any stove options that will make you comfortable?

Yes……1
No……2

F-4a1If yes, what? ……

F-4a2 Why? ……

SECTION G

CHILD CHARACTERISTICS

G-1 *NCHILD* No of children under five?

Enter the no……

G-2 *COOKPATERN* Please specify time and duration of cooking activities and number of children being cooked for

Time	**G-2a1** *CP1* No of children <5	**G-2a2** *CP2* Duration[Hr:Min]
Morning		
Afternoon		
Evening		

G-3 *TIMSPTKITCH* Time spent in the kitchen (within 1.5 meter distance of the stove) per day in hour

G-3a1 *TIMSPTKITCHCARG* Principal Caregiver…….

G-3a2 *TIMSPTKITCHCHILD* Young Child …….

G-4 *CHILDRESIDE* where do the children reside during the day time?

Indoor……01

Outdoor……02

G-5 What health problems are your children experiencing?

……

……

G-6 *TIMPROOCCR* When do these problems usually occur?

Morning? ……01

Afternoon? ……02

All day?……03

Every day?……04

Specific days of the week?……

G-7 *HOLDCHILDBACK* Do you cook while holding the child at your back?

Yes……1

No……2

G-7a [If No] how you keep the child

……

……

G-8 *ACCCHILD* Do children (<5 years of age) have accident experience related to cooking

Yes……1

No……2

G-8a [If yes] *ACCCHILD1*what was your measure?

Traditional treatment……01

Clinic visit……02

Others ……03, specify_____

ARI CHECKLIST

[Under five Children with cough and /or difficult breathing]

No.	Questions and filters (ARI-1)	Coding category [CC]
1	Has (NAME) had an illness with a cough at any time in the last two weeks?	**Yes.....** 1 **No.....** 2 **Do not know.....** 8
2	**When (NAME) had an illness with a cough, did he/she have trouble breathing or breathe faster than usual with short, fast breaths?**	**Yes.....** 1 **No.....** 2 **Do not know.....** 8

Sign/Symptoms of severe pneumonia or very severe disease (Put * mark)	
Chest indrawing	
Not able to eat or drink	
Unusually sleepy	
Convulsion	
Respiratory rate	

Diagnosis (ARI-DX)	
Simple cough and cold (no pneumonia)	1
Pneumonia	2
Severe pneumonia or very severe disease	3

Get references to fill the appropriate data

	CC1	**CC2**	**ARI-1** *CHAG* Age [month]	**ARI-2** *CHSEX* Sex	**ARI-3** *CHBOR* Birth Order	**ARI-4** *CHDX* ARI Diagnosis
Child #1						
Child #2						
Child #3						
Child #4						
Child #5						

Sex of child [1=Male, 2=Female]

Birth order: The child with the highest age in the household will be assigned 1 the second will be assigned 2 and so on until the youngest,

Consent for Focus Group Discussion

Thank you for your kindly response for this research questions and some other day, we will have a community centered discussion about this issue. In case we need you for that discussion your participation is voluntary. We will not take your time much.

Do you want to ask me anything about the discussion at this time?

Signature of interview..... Date..... End Time.....

Response: Agree for discussion.....01

Declines discussions..... 02

Annex II Illustrations

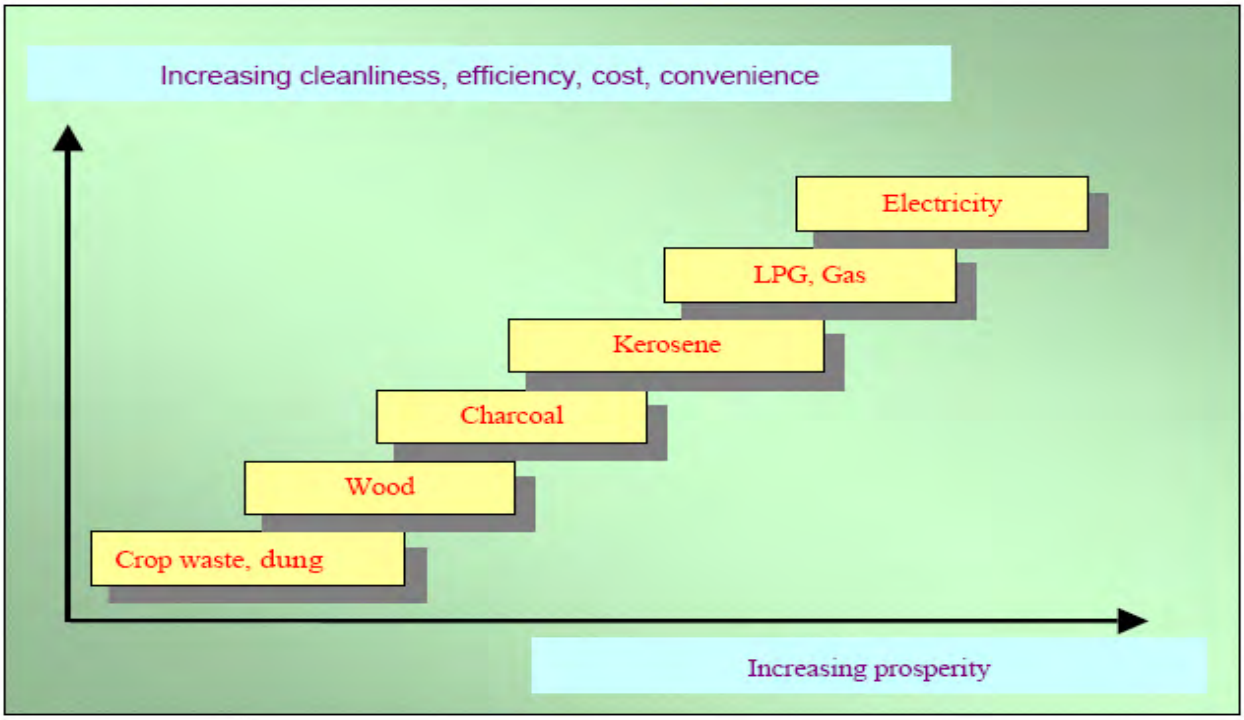


Illustration 1 Energy ladder (Source: Department of Public Health, University Of Liverpool, United Kingdom, 2002)

Energy ladder—The energy ladder is made up of several rungs with traditional fuels such as wood, dung and crop residues occupying the lowest rung. Charcoal, coal, kerosene, gas and electricity represent the next higher steps sequentially. As one moves up the energy ladder, energy efficiency and costs increase while typically the pollutant emissions decline.

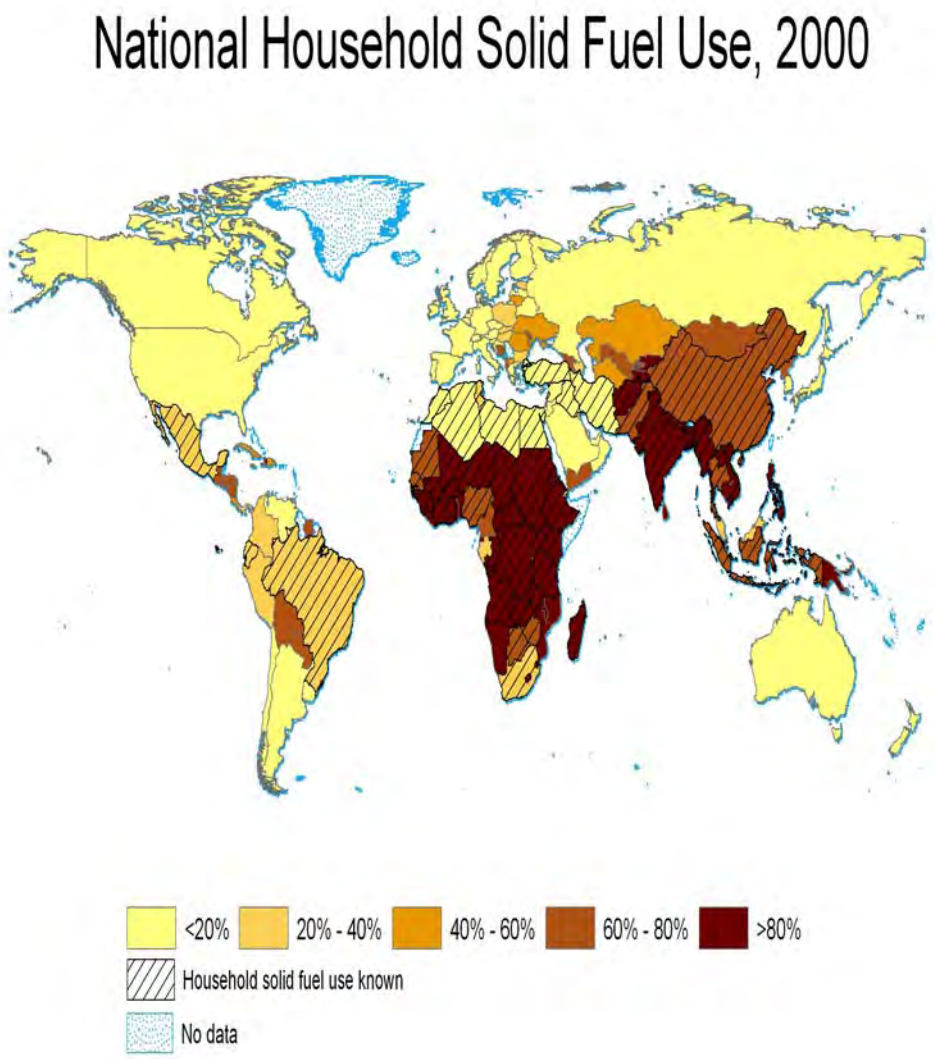


Illustration 2 National Household Solid Fuel Use, 2002 (Source: Department of Public Health, University of Liverpool, United Kingdom

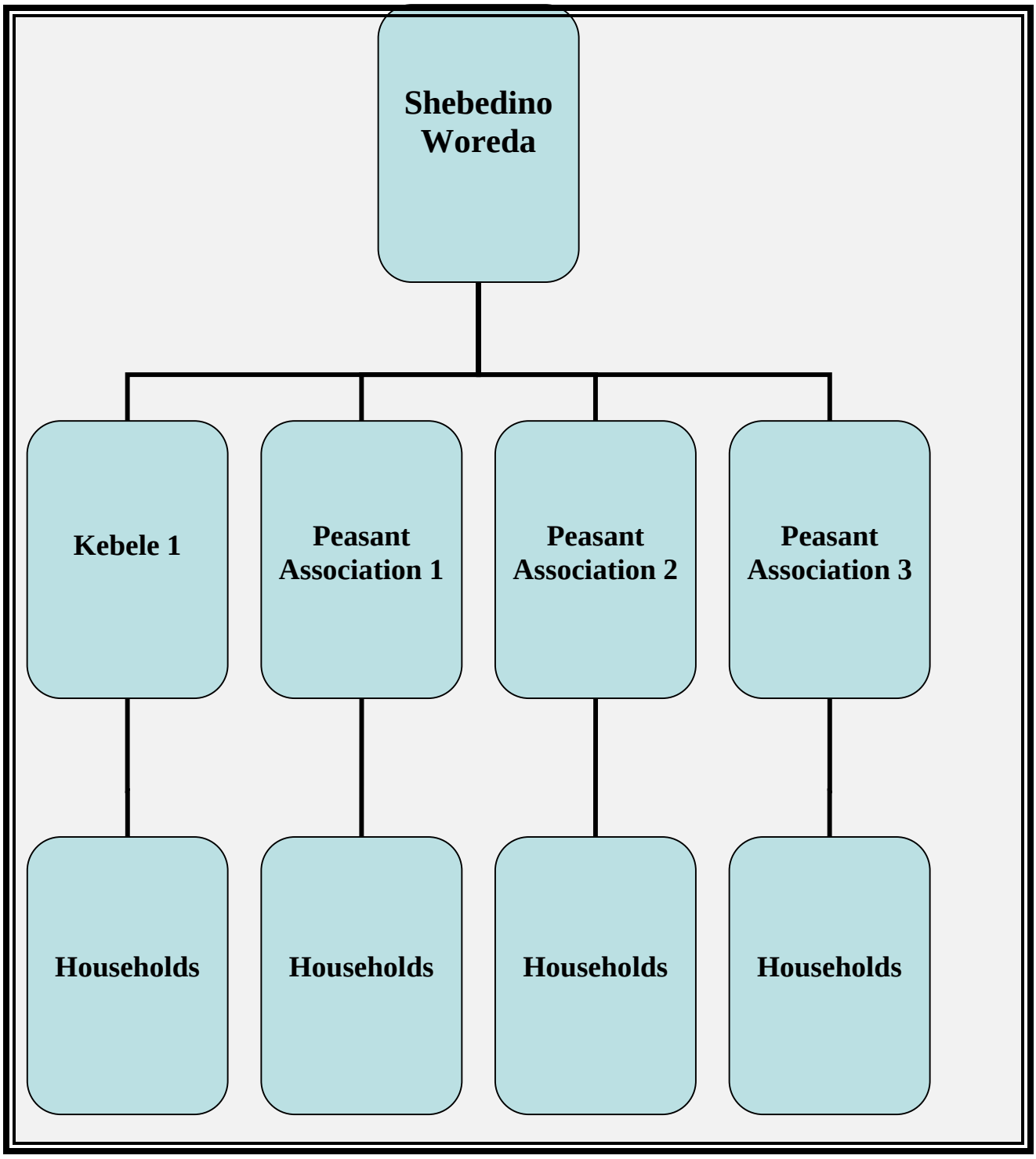


Illustration 3 Sampling Scheme

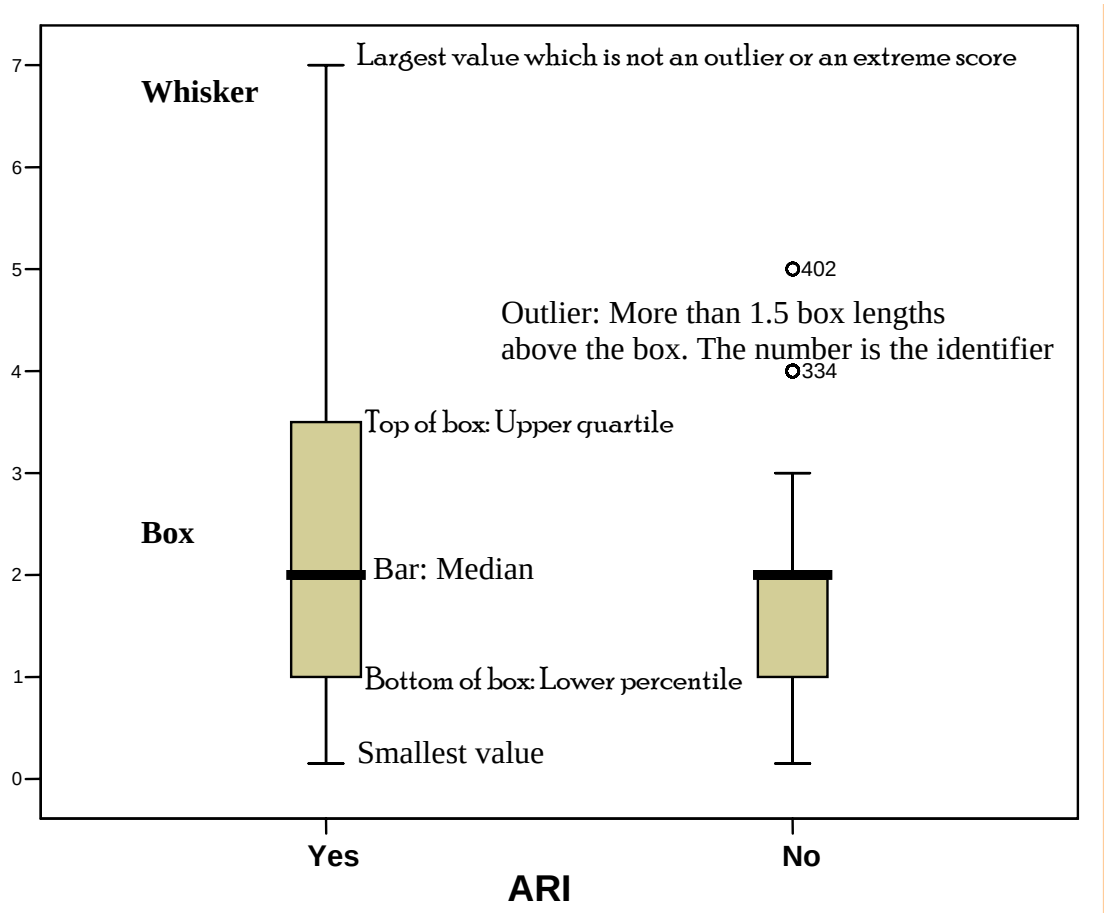


Illustration 4 Structure of a box plot

Box plot—A graphical method of presenting the distribution of a variable measured on a numerical scale. Summary plot based on the median, quartiles, and extreme values. The box represents the inter quartile range which contains the 50% of values. The whiskers are lines that extend from the box to the highest and lowest values, excluding outliers. A line across the box indicates the median.