ORIGINAL ARTICLE

Survey of Indoor Air Pollution Problems in the Rural Communities of Jimma, Southwest Ethiopia

Kebede Faris, MSc*

ABSTRACT

BACKGROUND: *The main energy source in both urban and rural communities in Ethiopia and elsewhere in developing countries is biomass fuel consisting of wood, cow dung, leaves, and agricultural residues. The health of people exposed to the smoke is affected due to the combustion products of biomass such as total suspended particulate matter (TSP), and gases such as carbon monoxide and poly-aromatic hydrocarbons (PAH). The types of health hazards mostly linked with biomass fuel are respiratory problems and eye disease from exposure to the smoke and heat. The main objective of this study was to assess the type of domestic fuel used, identify the environmental factors that may contribute to indoor air pollution, and determine the type of pollutants and persons mostly affected by the pollutants.*

METHODS: *A cross sectional survey was conducted between October 1999 and February 2000 to determine the type of domestic fuel used and status of indoor air pollution in the rural homes of Jimma Zone, Oromia region. The study involved 382 rural houses found in 13 localities (Kebeles) of four districts in Jimma. Rural communities of Jimma zone were stratified and randomized by districts and localities. The houses in the selected localities were further listed and randomized to select contact households. A questionnaire was used to collect information mainly on the type of houses, fuel type used, location and type of stove, time spent in cooking meals, etc. Smoke monitoring was conducted in kitchens using instruments and techniques as suggested by Heat. Measurements were taken near the stove and from the breathing zone.*

RESULTS: *The study revealed that the common domestic energy sources used for cooking and heating in all houses surveyed were biomass fuels such as wood, cow dung, leaves, corncobs, etc. It was also found that the great majority of households, 72.5% do not have a separate kitchen and 92% did not have windows for ventilation. Carbon monoxide concentration, suspended particulate matter and presence of poly-aromatic hydrocarbon (PAH) in concentrations greater than that which is recommended by WHO, indicate that the indoor environment of rural houses in Jimma zone is polluted. In addition the general unhygienic housing condition, inadequate floor space, location and type of stoves and lack of ventilation all indicate poor environmental condition to aggravate indoor air pollution problem.*

DISCUSSION: *Cooks and children are exposed to particulate matter and harmful gases in the home whenever a fire is lit for cooking or brewing.*

*School of Environmental Health, Jimma University, P.O. Box 378, Jimma, Ethiopia

Over 61% of the households showed pollutant levels greater than the recommended 0.15 mg/cubic meterof air. The recommended exposure time for people who will be exposed to more than 28.8 mg/cubic meter is only one hour while the cooks in the surveyed households are exposed to smoke for an average of at least 4 hours a day cooking, brewing or distilling. According to WHO, women exposed to biomass smoke for 2-4 hours inhale total suspended particulate (TSP) and benzo (a) pyrene (BaP) in amounts equivalent to smoking 40 cigarettes a day, which with long exposure will expose the smoker to lung cancer or heart problems.

CONCLUSION: *This study is by no means conclusive in identifying and quantifying types and amounts of indoor air pollutant as a result of biomass fuel use, but the result obtained is a strong indicator of the need for immediate interventions. Moreover, the data will be used as a baseline for a more in depth study.*

KEY WORDS: *biomass, diffusion tubes, gases, indicator tubes, injera, mitad, particulate, pollutant.*

INTRODUCTION

Jimma is one of the zones in Oromia regional state. It is located at latitude 7^0 23' to 8^0 47'North and Longitude of $36^0$04' to $37^0$30'East. The maximum and minimum temperature of Jimma zone is 27 ^{0}C and 21^0C respectively. In the southwest higher rainfall with lower elevation and higher temperature has produced extensive broad leafed rainforests (1).

Urban and rural communities in Ethiopia depend mainly on the use of traditional fuels like wood, dung, leaves, twigs, corncobs, charcoal and other biomass fuels. The use of these fuels will lead to substantial air pollution problem caused by carbon monoxide, hydrocarbons and particulate matters (2). These gases pollute the breathing air of those persons who are near the fireplace.

The types of hazards linked with biomass fuel use are: acute and chronic respiratory problems from indoor smoke; eye infection or disease from exposure to smoke and heat; negative reproductive outcomes from emission exposure and load carrying (for low birth weight); nutritional deficiencies linked to fuel shortage; accidents predominantly burns, and scalds from open fire (2,3).

Health effects associated with exposure to indoor air pollution as a result of biomass fuel use have not been very rigorously investigated (3,4). Generally combustion products, chemicals and biological agents cause indoor air pollution (IAP). Research in developing countries, however has now focused on combustion-generated products, principally from biomass fuels (5).

Studies that compared gas stoves with solid-fuel-fired cooking and heating stoves indicate that even stoves, using one of the cleaner bio-fuels -wood, typically release 50 times more particulate, carbon-monoxide (CO), simple as well as poly-aromatic hydrocarbons (PAH) in cooking an equivalent meal using fossil fuel (4,5). Although there are numerous confounding factors that tend to obscure the link between biomass fuel and respiratory disease, Pandy *et al.* found that the level of particulate from indoor air pollution in rural areas of developing countries is 10,000 microgram/ m3 (6). Empirical evidence has shown that unprocessed solid fuel produce hundreds of chemical compounds because of the incomplete combustion that occur under the operating conditions of simple cook stoves, which are often little more than three rocks or a small open ended box of clay (5). Several studies have pointed out that many pollutants are more concentrated in the indoor environment than in the outside (7).

The potential health effects of biomass smoke, especially to eye disease and respiratory infection, is well established by the World Health Organization (WHO). Infants and young children of under five years are highly affected by indoor air pollutants. Smith, Collings, and Achemedi (5,7,8,) observed during a three-month cohort study of acute respiratory infection (ARI) among children under five. They found that episodes of ARI are closely related to independent variables such as the degree of indoor air quality, ventilation (air flow and mixing volume), number of people per square meter (density), and socio-eçonomic status. The risk of ARI was identified as approximately four times as great for those children living with lower indoor air quality than for the control groups.

Although the magnitude of the health problems associated with indoor biomass smoke pollution has never been documented in Ethiopia, the comprehensive health records in Ethiopia (9) shows that ARI and eye diseases are among the top ten diseases. Kloos *et al* (10), stated that 5.8% of all new outpatients in 1988-89 had ARI. More than one-third (36%) of 399 inpatients upon admission to Black Lion Hospital in Addis Ababa had pneumonia. Muhe (11), also mentioned in his study that among the 3500 admissions to a children's hospital in Addis Ababa, 11% were diagnosed as having diseases of the respiratory tract. Cases with pneumonia as the principal diagnosis constituted 6% of admissions and 7% deaths. In a study of younger children in South Africa, Kossove found that 70% of Zulu infants with respiratory symptoms lived in households with cooking fire smoke compared to 33% of a partially matched group who did not have such symptoms (12).

In rural areas of Africa a substantial portion of infants, children and women are exposed to debilitating levels of indoor pollution caused by biomass fuel use, which has an inefficient combustion process and a very high particulate matter emission (3). Pandy *et al* (13) conducted an epidemiological survey of infants and children in Nepal. The study assessed the relationship between time spent per day near the cooking stoves and episodes of life threatening, or severe ARI. The fuel used was mainly wood and crop residue and the houses were unventilated. The study shows that there is a statistically significant association between length of exposure and number of episodes of ARI.

Even more than the acute effects, chronic disabilities may arise from the prolonged use of biomass fuels in poorly designed and situated cooking stoves in rural village huts. Opacity of eye lens and other chronic disabling ocular lesions may result from repeated acute inflammatory conditions of the conjunctiva caused by the irritant effect of emission from bio-mass fuel (4).

The main objective of this study was to assess the type of fuel used, determine the type and amount of indoor air pollutants and assess the type of stoves used in the rural communities of Jimma, Oromia region. Moreover, the study aimed to determine housing ventilation and the duration of exposure of individuals involved to the indoor air pollutant.

MATERIALS AND METHODS

Study period, site and design: The cross sectional study was conducted between October 1999 and February 2000. A

questionnaire study was first done from which houses with children under five years of age were identified. The study implemented using a structured interviewer administered questionnaire and hand held air-monitoring instruments in 13 rural villages of Jimma Zone. Indoor air monitoring was then conducted on those selected houses with children under five years of age.
Convenience or non-probability sampling was applied to select the four districts. The rural villages found in the selected districts of Jimma were stratified and randomized by districts (Woreda) and sub-woredas (Kebeles). Once the kebeles or localities were identified households were listed and contact households were then systematically sampled.

Since the study was intended to estimate the extent of indoor air pollution in the rural communities who are using biomass fuel, a sample size adequate to estimate this value with adequate precision was calculated using an appropriate sample size calculation formula as noted by Daniel (14). Accordingly, 382 households in rural communities of Jimma were selected for the study.

Data collection: Quantitative and qualitative data were collected using structured format and measuring instruments. A structured questionnaire was prepared to collect information mainly on: housing type and ventilation, type of stove, type of fuel, time spent cooking meals or brewing beverages.

The questionnaire was first prepared in English and later it was translated into Amharic. The Amharic version was pre-tested in rural settings similar to where it was going to be used for the quality and clarity of translation. Pre-testing was also used to train enumerators on interviewing techniques.

Data collection was effected using trained data collectors and environmental health professionals. The investigator and other professional colleagues conducted overall supervision and indoor smoke monitoring using hand held instruments.
Smoke monitoring in the indoor environment was conducted in kitchens to determine total suspended particulate matter (TSPM), carbon monoxide and hydrocarbon using instruments and techniques as suggested by HEAT (15):

Bacharach sampler with cotton filters:

A hundred liter of air from the contaminated area was sucked using a hand pump fitted with the cotton filters to check for gray shade/ black soot. The cotton filter was then optically analyzed using the chart by Brigon and as suggested by Baum (16). It is further tested for the presence of aromatic hydrocarbons such as BaP by washing the soot trapped by the filter using acetone.

Gray shade (Black Smoke test)

IV…Gray shade No. from Brigon chart in mg/m3
F. at…1013/790 =1.28
Concentration = IV x F. at,
where Con= Concentration

A manual pump with membrane filters:

was also used to sample particulate matter. The filter was first put in an oven for 24 hours and weighed. After sampling it was put back in an oven to remove humidity and weighed again. The difference between the final and initial weights is taken as the weight of total suspended particulate matter (TSPM). An analytical balance with precision of 0.0001 was used to weigh the initial and final weights.

Total suspended particulates:

TSP..=> Total Suspended Particulate
DW..=> Final weight minus initial weight of filter
SV ..=> Total volume sampled in m^3 (volume of hand pump) (0.163 x No. of stroke)
Con =DW/SV

Carbon monoxide was measured using diffusion and indicator tubes as suggested by the manufacturer Drager AG (16). The diffusion tubes were clipped into the collar of the cooks for as long as it took to finish cooking. Indicator tubes were inserted in a Drager gas detector hand pump where air was drawn from the breathing zone of the cook. Color change shows the presence of pollutant whose concentration is read visually from the scale reading inscribed on the tube (15).

Carbon monoxide concentration:

IV… => Indicator value
F. AT.=> Factor for true atmospheric conditions (1013/790=1.28)
Con. .=>Concentration

Con= (Ivxf.atx60min/hr)

The samples were taken when cooks were normally cooking *injera* (Ethiopian pancake type bread) or sauce. Injera baking and sauce preparation activity was preferred for monitoring because women stay near the stove for a longer period of time as the two activities need frequent attention. Measurements were taken near the stove and from the breathing zone at three phases: when the fire is just lit, when there is full fire, and post cooking time. The three measurements were averaged to give one exposure reading.

The intent of the study was fully explained to village leaders and others concerned in the locality where the study was conducted. Households were also informed about the study and the procedures involved. Both the local leaders and individual households granted permission to conduct the questionnaire and indoor air monitoring study. Confidentiality and anonymity of participants was ensured.

Data processing: Data from the questionnaire survey were processed using SPSS/ PC software computer program. Data on gas and particulate monitoring were processed using a hand held calculator.
The study did not plan to do statistical correlation or associations except to see the extent of air pollutant in the living environment. However, comparison of the study results was made with that of standards given by WHO and findings of similar studies in other countries.

RESULTS

Thirteen villages (Kebeles) were selected from four districts (woredas) in Jimma zone (Table 1). Children of under five years of age were found in 48.6 % of houses surveyed in the rural communities of Jimma. Most of the children are in the age range of less than 12 to 35.5 months.

Table 1. Number of house holds selected for indoor air pollution study in rural community of Jimma zone, Oct 1999-Feb 2000.

Seka district	Dedo district		Kersa district					Omonada district				
Kebele	Kebele		Kebeles					Kebeles				
Kishe	Cho ma	Bilo	Sito	Adi ch	Wi gh	Babis	Toly	Ab	Wo nji	Aso bile	Seyo	Gw os
77	39	26	14	21	25	25	22	31	27	25	26	24
Total household surveyed =382												

Houses, Kitchens and Stoves:

A round, mud or dung plastered house with thatched roof is common in the rural communities of Jimma, Out of those rural houses surveyed 46.0% and 45% are one and two-roomed units (Fig. 1).

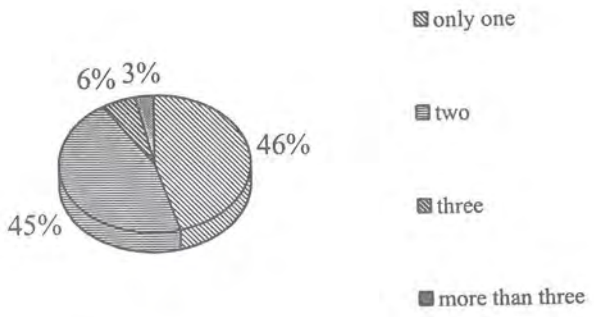

Fig 1. Number of rooms a house possesses in rural communities of Jimma Zone, Oct.1999 Feb. 2000

The means of ventilation used are windows and opening doors especially during cooking or baking. However, the number of households that always open windows and doors and those with a proper chimney for ventilation were found to be only 8% and 11.5 % respectively. Other ventilation methods include: opening the roof, arranging holes at the eaves of the house and opening a hole about 20 centimeter diameter in the wall above the stove.

During the survey, stoves were observed to be located in the middle of a living room, in a separate kitchen outside the house or in a separate location within the main house. However, a separate

The traditional three stone stoves is preferred by the users, basically because it could be narrowed or expanded to accommodate narrow or wide bottom cooking utensils like 'saucepan ' or 'mitad' (injera baking pan). The average height of any traditional stove from the floor is 0.35 meters. The injera mitad, which is thick and flat, is about 0.45 meters in diameter. A traditional bread making clay utensil is even thicker, smaller in diameter and deeper. Traditional cooking and baking utensils consume a lot of energy to heat.

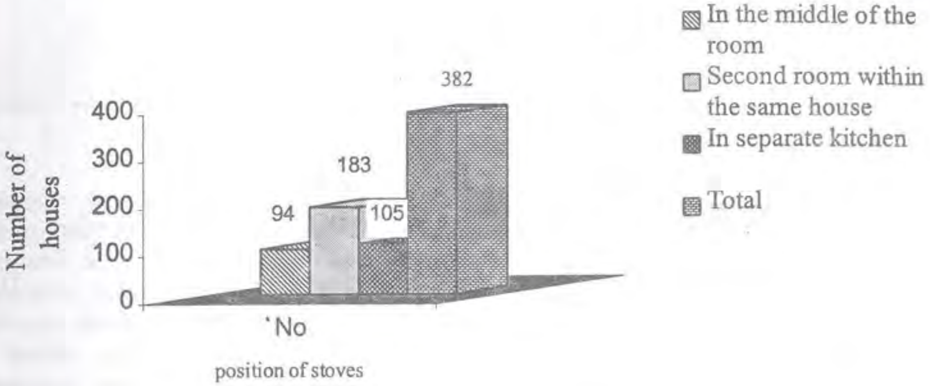

Fig. 2. Location of stove in surveyed houses in rural communities of Jimma, Oct1999-Feb 2000

The common biomass fuel used for njera making, sauce making, coffee rewing or boiling tea is wood, leaves, crop esidue, sawdust and oil cake. Cow dung is ot very much used in rural communities of imma except by a few settlers in Kishe rea who had come from the North (Tigray nd Wollo) where wood is scarce.

Among the biomass fuels, wood is a umber one choice for 85.9% of rural ommunities of Jimma. Animal dung was lso rated as number one choice by 14.1% f the rural communities of Jimma.

The mother is the one most engaged nd most exposed to indoor air pollution ue to her cooking activities using biomass uel as shown in table 2

Table 2. Share of family members in cooking activities in rural communities of Jimma, Oct 1999- Feb 2000.

Family member	Number	%
House mother	346	91.1
Daughter	31	8.1
Others (maids etc)	3	0.8
Total	380	100.0

These members spend most of their time every day cooking meals (breakfast, lunch and dinner) brewing coffee, boiling tea, etc. Most have claimed to spend 1 to 3 hours while few claimed that they spend 4 or more than five hours cooking (Table 3).

Table 3. Time spent by chief cooks, cooking meals in the rural community of Jimma, Oct 1999- Feb 2000.

Type of food & beverage prepared	Time spent preparing food and beverage (hours)				
	1-2	2-3	3-4	4-5	>5
Lunch	333 (92.2)	28 (7.8)	-	-	-
Dinner	171(48.7)	126 (35.9)	24 (6.8)	25(7.1)	5 (1.4)
Brewing coffee	213 (80.2)	17 (6.4)	29(11.0)	3 (1.1)	2 (0.8)
Distilling liquor	6 (4.0)	2 (13.3)	-	-	-

Note: Numbers in parenthesis are percentages of cooks who claimed to be working in the task and time specified

Indoor Air Monitoring Result:

The structured survey was conducted on 382 households. Out of the households surveyed those with children under five years of age were randomly selected for the field test.

The most important pollutants released in the process of biomass energy use are particles, hydrocarbons, carbon monoxide, formaldehyde, sulfur and nitrogen oxides. Due to unavailability of resources to conduct all the necessary tests, only TSP, soot-tar test or particle shade test, and carbon-monoxide tests were performed.

Authorities who devoted several years in the study of indoor air pollution recommend that for health considerations, measurements and control are best focused on TSP matter. The smallest inhaleable particulates are those with size less than 10 micrometers. This study was not able to quantify particulate of that size due to lack of instruments. The instrument for identifying smaller size particulate should be a type that stimulates what happens in the human respiratory system following particle inhalation. But, it is assumed that all combustion processes generate smaller particles. This study revealed that women cooks spent many hours cooking and thus they are exposed to particulate matter, hydrocarbons and carbon monoxide (Table 4).

Although the instruments used are by no means expected to give very reliable information on the exposure of the individual to any particular pollutant, they have provided indications of serious pollution by particulate, CO and BaP.

Table 4. Indoor Air pollutant monitored in households in rural community of Jimma, Oct 1999- Feb 2000.

Questionnaire Result			Indoor Air Monitoring Result								
No	House type	Fuel type	Co PPM/hr			Particle shade mg/m3			TSP mg/m3		
			IV	f.at	Con.	IV	f.at	Con	S.V	DW	Con
1	Thatch	Wood	15	1.28	115.2	90	1.28	115.2	0.0163	0.006	0.37
2	"	"	10	1.28	76.8	22	1.28	28.2	0.0163	0.0024	0.15
3	"	"	2	1.28	15.4	26	1.28	33.3	0.0163	0.0018	0.11
4	"	"	5	1.28	38.4	22	1.28	28.2	0.0163	0.0015	0.09
5	"	"	25	1.28	192.0	260	1.28	332.8	0.0163	0.0061	0.37
6	"	"	18	1.28	138.	36	1.28	46.1	0.0163	0.0015	0.09
7	"	Wood, corncob	10	1.28	76.8	125	1.28	160	0.0163	0.0005	0.03
8	"	"	40	1.28	307.2	90	1.28	115.2	0.0163	0.0005	0.03
9	"	Wood, twigs	2	1.28	15.4	22	1.28	28.2	0.0163	0.0009	0.05
10	"	Wood, corncob	2	1.28	15.4	36	1.28	46.1	0.0163	0.0009	0.05
11	"	Wood	2	1.28	15.4	22	1.28	28.2	0.0163	0/0022	0.13
12	"	Wood, twigs, cow dung	20	1.28	153.6	36	1.28	46.1	0.0163	0.0030	0.18
13	"	Wood, corncob	5	1.28	38.4	7	1.28	8.96	0.0163	0.0015	0.09
14	"	Wood	2	1.28	15.4	54	1.28	69.1	0.0163	0/0065	0.40
15	"	Wood. Leaves, cow dung	10	1.28	76.8	260	1.28	332.8	0.0163	0.0058	0.36
`6	"	Wood, leaves	6	1.28	46.1	125	1.28	160	0.0163	0.0061	0.37
17	"	Wood, leaves	10	1.28	76.8	14	1.28	17.9	0.0163	0.0051	0.31
18	"	Wood	9	1.28	71.1	54	1.28	69.1	0.0163	0.0061	0.37

Carbon monoxide concentration **Particle (black smoke test)** **Total Suspended Particulate**

Con= (Ivxf.atx60min/hr) **con = IVxF.at** **Con. = DW/SV**

DISCUSSION

The study clearly indicates that there is an indoor air pollution problem in the rural areas that were surveyed. The problem emanates from the fuel, the technology used to burn the fuel (stove construction), and lack of a separate kitchen with proper ventilation or chimney. Many persons associate air pollution with industrialization; mostly in urban areas, and with combustion of fossil fuel only. However, this study and that of Kosove, Global Environmental Monitoring System (GEMS), United Nations Environmental Program (UNEP) and World Health Organization (WHO) (4, 12,17), demonstrated convincingly that the greatest indoor concentration of and exposure to many important pollutants are found in both rural and urban households of developing countries.

The quality of wood, leaves, corncobs, dung and other biomass fuels is such that it produces a lot of smoke particulate and gases. Among these, dung fuel is considered one of the poor quality fuels. In this study all monitoring results where there was cow dung among the fuels used in the homes, indicated that the concentration of TSP, CO and PAH was high (Table 4). Another monitoring result from Tigray where cow dung cake was the most frequently used fuel shows a carbon monoxide concentration of up to 600 PPM, and a TSP production of between 83-175 mg/m3 (19).

As indicated by a WHO commission who studied bio-mass energy use, women spending 2-4 hours a day at the stove, inhale TSP and BaP in amounts equivalent to smoking 40 cigarettes a day (20). Although particle size is not determined, total suspended particulate measurement indicates a pollution problem, taking the international working standards of 0.15mg/cubic meter.

The acetone wash test done on the cotton filter sample taken from kitchens shows yellow coloration indicating the presence of hydrocarbons molecules (BaP), which occur during burning of biomass fuel and which is suspected as a carcinogen (15). It was not possible to quantify the amount of hydrocarbon present due to a lack of resources such as gas chromatography.

Carbon monoxide is a gas produced as a result of incomplete combustion. It has a strong affinity for hemoglobin, forming carboxy hemoglobin (COHb). In indoor environments, the link between concentration and COHb level depends on duration of exposure and degree of physical activity. In this study it was found that cooks spend a minimum of 2-3 hours and as much as 5 hours cooking one meal exposing themselves to different pollutants (Table 3). This study did not determine the COHb level in cooks that are exposed to smoke of biomass fuel but a study made on two villages in Guatemala shows lower COHb levels in women cooking in well-ventilated kitchen indicating that the COHb level will be worse in an unventilated working environment (23).

The health risk associated with indoor air pollution resulting from biomass fuel use is not well documented. Some studies conducted to see the associations of lower respiratory infection of children was not conclusive due to sample size and confounding factors such as malnutrition status of children and hypovitaminosis A and anemia (11,12). Indoor air pollution affecting the health of the child, especially those under five years of age is aggravated because children and adult mothers stay for a longer time near the fire than others. Children often accompany their mothers, sleep near stoves or rest on the back of their mothers when the mother is busy baking or cooking with an open fire where exposure to pollution is at its maximum.

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Biomass fuel or other fuel use by itself may not be a risk but the risk may increase with the indoor environment and also, according to Kosove (12), with duration of use or exposure. This study demonstrated that the chief cook and the eldest daughter stay near the stove for more than three hours. The standard criteria by WHO states that a COHb for those engaged in different type of work including cooking should be within 2.5%. A person must be exposed to 57.5 mg/m3 for 30 minutes, or 28. 8 mg/ m3 for one hour or 11.5 mg/m3 for 8 hours. In this study cooks have been found to be exposed to concentrations of pollutants greater than the amount recommended. International standards also indicate that the total suspended particulate matter should be less than 0.15 mg/ cubic meter. This study showed concentrations of particulate matter much higher than this standard in 56.1% of the households (Table 4). Furthermore, health effect is not only on exposure to smoke and heat but also during production (dung preparation, charcoal production), collection (trauma, reduced child care, bites from wild animals and snakes, allergic conditions to molds or fungus) and ergonomics (carrying, sitting) [19].

In conclusion, three very important parameters have been used to see whether indoor air pollution is a problem in rural homes. The parameters selected are carbon monoxide, particulate matters, and poly-aromatic hydrocarbon (PAH) indicator. The presence of these pollutants in a living environment in excess of human tolerance indicate that those exposed, especially small children and mothers, are or will eventually suffer from problems associated with the pollutants including lung cancer. Table 4 shows that almost all houses surveyed have one, two or three pollutants in excess of the recommended limit.

Although this study is by no means conclusive in identifying the types and amounts of indoor air pollutants, it at least will motivate us to seek intervention and to conduct more in depth study, preferably longitudinal studies to correlate the pollutant with health effects.

RECOMMENDATIONS

Biomass fuel use in Ethiopia will continue to be the only choice in the future. There seems to be no alternative because fossil fuel such as kerosene, gas and electricity are becoming very expensive. A study was made to compare the cost of biomass fuel and electricity to bake an equal amount of injera using improved stove and electric mitad at four different cities in Ethiopia (21). The result shows that using wood is cheaper than using electricity in all four areas, which indicates that even if electricity or fossil fuel were available in the future, the cost may be prohibitive to use it.

The effort should therefore be aimed at:

1. Technology (Improving the Traditional Stove)

Improving the efficiency of stoves will decrease the amount of wood consumption. When burning is efficient the rate of carbon monoxide generation will also decrease. Proper stove design will also incorporate accident prevention and smoke evaluation mechanisms. Using improved stoves, with ventilation and chimney, reduces the emission to indoor air by up to 60 % for suspended particulate matter, 86 % carbon monoxide and 30 % aldehydes (22).

2. Health Education

Health education is necessary so that people, especially the cooks and children, will not expose themselves to biomass smoke pollutants. They should be aware of the importance of ventilation, separate kitchens and accidents related to the production, collection or use of biomass fuels.

National and regional "awareness creating" campaigns are needed to promote energy consumption and stove efficiency. Like any development program, households should be made aware about the impact of deforestation to health and production.

3. Further Research

It is necessary to conduct a comprehensive and longitudinal study on the health effects such as ARI, birth impacts, accidents and other suspected health problems and energy sources, using " natural experiment" with and without interventions such as improved stove, chimney or hood over fire. It is also necessary to monitor specific energy sources with respect to the heat it produces, pollutant (type and concentration) it emits, and its fate in the closed living environment using precise instrumentation. In order to evaluate the extent of exposure, studies should also be conducted at different altitudes and temperature ranges.

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