



## An assessment of Indoor Air Pollution with special references to cook stoves in Western U.P Region

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### ABSTRACT

The paper seeks to investigate the risk factor associated with indoor air pollution in low income households. Cooking with traditional fuels leads to high levels of indoor air pollution expose of which increase the risk of various health problems health problems. The present study is based on the collect information on socio-economic condition, types of chulla used, its location, types of fuel, fuel sources and health consequences in the rural area of Muzaffarnagar and Bagpat district of Uttar Pradesh. The study provides the overview of the relation between indoor air pollution (IPA), traditional cooking stove, fuel used, literacy, health and economic well being. The result shows that most of income households were using traditional fuels and stoves, cooking in multipurpose room and veranda in poorly ventilated cooking places and taking long hours for cooking. The study points to the need of creating awareness amongst low income households.

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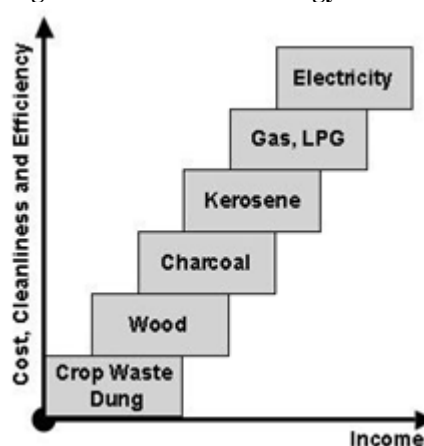
### Introduction

Indoor air pollution (IAP) remains a potentially large global health treat. One half of the world population and up to 95% in poor countries continues to rely on solid fuels, including biomass fuels wood, dung, agricultural residues and coal to meet their energy needs. Cooking and heating with solid fuels on open fires or on traditional stoves generates high levels of health-damaging pollutants such as particulates and carbon monoxide. As women are primarily responsible for cooking and as children often spend time with their mothers while they were engaged in cooking activities women and young children are disproportionately affected. (Holdren *et al.*, 2000). In our country air pollution studies particularly in rural households has so far been neglected. It is recently estimated that 82% of sulphur oxide, 38% of nitrogen dioxides, 88% of volatile organic compounds and 96% particulate matter emission in the country come from the household sector (Parikh, 1999). According to the recent finding indoor air pollution is five times more hazardous than outdoor air pollution and major sources, the solid fuels is second most environmental causes of diseases after water borne diseases and fourth most important of overall excess mortality and burden of diseases (WHO, 2000). The most significant issues that concerns indoor air quality in household environment is that of exposure to pollutant released during combustion of solid fuels, including biomass or coal used for cooking and heating. Most of the household using these fuels burn in inefficient earthen/ metal stoves or in chulla ('U' shaped stoves made of mud and brick) in poorly ventilated kitchens resulting in very high concentrations of indoor air pollutants. Households at lower levels of income and development trend to be at the bottom of the energy ladder, using fuels that are cheap and locally available but not very clean nor efficient (see figure)

Air pollution is a significant cause of morbidity and mortality. The amount of exposure in terms of the number of people exposure intensity and time spent is far greater in developing world (Smith, 1993). The most important are particles, carbon monoxide, nitrogen oxides, sulphur oxides, formaldehyde and polycyclic organic matter, including

carcinogens such as benzo (a) pyrene (De, Koning, *et al.*, 1985). Indoor air pollution mostly health though inhalation, but can also affect the eyes through contact with smoke. Despite the magnitude of growing problem, the health impacts of exposure to indoor air pollution have yet to become a central focus of research. Keeping these aspects in mind in this paper an attempt has been made to raise awareness about the indoor air pollution (IPA) as a critical rational in western U.P region.

Figure : The Classic "Energy Ladder"



This ladder describes transitions in fuel use at different levels of economic development

Source: Holdren and Smith (2000).

### Material And Methods:

#### Study area

The two districts of Western Region of Uttar Pradesh in the fertile Doab region of Yamuna and Ganges rivers namely Muzaffarnagar and Baghpat were selected for the study. Baghpat is located on the banks of river Yamuna at 28°57' North Latitude and 77°13' East Longitude with total Area of 1,321 Sq Km and Population of 1,163,991. Muzaffarnagar district lies between 29°11'30"N and 29°45'15"N and between 77°3'45"E and 78°7'E. Its total area is 4,049 Sq Km and has a population of 4,138,605. Four villages, two each from

Muzaffarnagar (Kukra and Bajitpur) and Baghpat (Bhadal and Lohadda) were selected for the survey.

#### Study design

Surveys were conducted in the rural area of western U.P. covering 2910 individuals in 433 households in four villages from two districts during the period of January to March 2012. The questionnaire was designed in English and translated into Hindi for better understanding of the surveyors and the respondents. The respondents for socio-economic and other variables were the women in the household. Each household is provided oral consent before enrolling in the study. (Annexure).

#### Development of questionnaires

A questionnaire was prepared on the basis of purpose of study and with the help of questionnaires used in earlier studies (Smith, 1990; Lioy, 1990; Bruce, Prez-Padilla and Albalak, 2000; Ezzati and Kammen, 2001; Singh, 2002-2003). Information regarding the socioeconomic conditions, type of chulha used, type of fuel used for cooking, place of cooking food, health and economic status were collected.

#### Household selection

The villages were selected by using judgment sampling which is a common non-probability method. Households from each village were selected by using random sampling, commonly used probability method. The selection of villages and households is given in table 1.

#### Result and discussion:

The results obtained from the present investigation are presented below:

#### Socio-economic conditions

The socio-economic characteristics (Economic status, occupation, female literacy) in all the sampled villages were found more or less similar. The socio-economic information gathered from household survey of four villages with the help of questionnaires interviews is presented in the Table 2. In the present survey economic status of the households sampled was found 47.75 % middle class, 41.75 % poor and 10.5 % below poverty line (BPL) (Figure 1). Economic status is an important factor in the similar studies that reported the issues of household energy (Laxmi *et al.*, 2003; Singh and Jamal, 2011) as it influence the man's way of living, location of residence, type of house and access to various amenities and facilities. It also determines the choice and quality of energy use. It is well recognized that with rise in economic status, energy used is upgraded. The majority of the villagers were found either small or marginal farmers in the present study. About 51.5 % of the adults were engaged in the farm based activities, 63.75 % in animal rearing, 50 % were found landless and worked on daily wages while 25.75 % were involved in teaching and other services and lived outside (Figure 2). Agricultural practice and animal rearing was also a source of fuel for them. Families having their own land and animals did not have to pay or collect fuel from others farm, hence less drudgery for women and children in comparison to landless families which undergo more adversity during fuel wood collection.

Prevalence of education was low in all sampled area as most of the females were uneducated. The present study showed that 51 % of the females were illiterate in the sampled area, 11 % were educated up to 5<sup>th</sup> standard, 13.75 % up to 10<sup>th</sup>, 13 % up to 12<sup>th</sup> and only 11.25 % were found graduate and above (Figure 3). An educated household will be aware about IAP and will always think of using clean cooking fuels emitting less pollutant. A total of only 49 % females were found literate. The rate of literacy was found more in middle class families and less or negligible in poor and BPL families. According to our sample, level of female literacy was very low as only 49 % of

females were literate against 65.46 % female literacy for all India (Census of India, 2011). Our survey results for the female literacy rate was also much below the census 2011 report 59.2 % for U.P. (Figure 4).

#### Household and kitchen characteristics

The household and kitchen characteristics found in the present survey are presented in Table 3. Location of kitchen, number of rooms and ventilation conditions are very important variables affecting intensity of indoor air pollution and exposure suffered by different members of the household (Smith, 1987). Singh and Jamal (2011) studied risk factors associated with IAP in low income households and found that 29.27 % of low income household stays in only one room facility while 70.73 % in two or more room in Aligarh whereas the housing conditions of the surveyed households in the present study was found better where only 4.75 % of the households were living in single room house and 44.75 % households have only two rooms. About 50.5 % of the houses have more than two rooms (Figure 5). In about 64 % households more than two children (range 3-12) were found and in about 90 % households more than one family lives which shows congestion and crowding in most of the households. A majority of households were user of traditional stove. It was also noted during present study that people prefer traditional stove over LPG cook stoves. Similar trends were also recorded by Duflo *et al.* (2008); Singh and Jamal (2011); Laxmi *et al.* (2003).

In the present study data revealed that about 48.5 % of the households have only traditional chulha for cooking food (Figure 6). About 30 % household have LPG stoves along with the traditional stove while only 20.5 % of household have traditional stoves, LPG stoves and electric heaters. However, Duflo *et al.* (2008) conducted similar study in rural Orissa where only 4.6 % of households own a LPG stove and 11.4 % electric stove. In the present study percentage of household using LPG stoves and electric heaters is more compared to Orissa. None of the household using kerosene stove was recorded during present study. Cooking with traditional methods without proper ventilation has adverse impacts on human health (Smith, 1996). Improper ventilation is considered as a major risk factor associated with IAP in rural Orissa and rural Rajasthan (Duflo *et al.*, 2008; Laxmi *et al.*, 2003). From the total sampled households in the present study 89.75 % of households have set their stoves in the open area (Figure 7).

#### Fuel characteristics

Table 4 shows that almost all the households in the rural area use dung cakes, crop residues and wood for cooking. These types of solid fuels remain the principal household fuel for around 3 billion people and since their use is closely linked to poverty this is also a population with generally poor access to health care (Dherani *et al.*, 2008). The majority of household, about 92.25 %, in the present study used dung cakes (Figure 8). This is because a majority of household is involved in animal rearing and dung cakes are easily available. Wood and crop residue was used by 25 % and 26.75 % of households respectively. The average daily consumption of resources in the present study was found about 10.4 kg per household. Kerosene has wide accessibility and use in the rural areas, and is the next clean fuel on the energy ladder after fuel- wood (Leach, 1992). However in the present study kerosene was only used for ignition and its use for cooking was negligible in the surveyed area as its availability was limited. Similar condition has been observed in the rural Rajasthan (Laxmi *et al.*, 2003) where kerosene was not used for cooking, because of unavailability more than non affordability. About 67.75 % of household in the present study were found to have their own resources for fuel

wood whereas 32.25 % either purchase it from the market or collect it from others land (Figure 9).

Usually, people give more emphasis to fuel gathering than to purchase it. This is because the fuel they gather is freely available to them and they don't have to pay for it. Purchasing is done when the stock of collected fuel is all over. In India, the time spent collecting fuel is estimated at an hour per day (World Bank, 2002). Gathering fuel-wood involves a lot of hardship in walking long distances and carrying head-loads of fuel-wood that can cause health disorders in individuals (mostly women and children). Wickramsinghe (2001) and Parikh (2002) have drawn attention to the health impact of collection and carrying heavy loads of fuel on the neck, back and head. The distance walked to collect fuel-wood in present study was from 1 to more than 3 km (Figure10).

Fuel-wood gatherers on an average spend 3 hours per trip, thus spending a lot of time in fuel-wood collection. This effort, if put to some productive use, can help reduce the drudgery of women and children, as they are the one generally associated with gathering, processing and transportation of fuel-wood. Similar conditions were reported by Laxmi *et al* (2003) in rural Rajasthan where fuel-wood gatherers made 16 trips per month and spend 3 hours per trip, thus spending about 50 hours a month in fuel-wood collection.

#### Health characteristics

Table 5 shows the health characteristics of sampled households. Cooking with traditional methods without proper ventilation has adverse impacts on human health (Smith, 1996). Women and children are more exposed to smoke from traditional stoves as women are involved in cooking and children spend most of the time around their mother. The World Health Organization has assessed indoor air pollution as the 8th most important risk factor to the burden of diseases. High exposure to pollutants released during burning of bio-fuels in traditional stoves for cooking (particulates, carbon monoxides and a range of organic compounds including formaldehyde, benzene and benzopyrene etc.) have been associated with serious health problems and as women are involved in cooking, they are the sufferers because they spend long hours before fire and smoke (Singh, 2004).

During the present survey cough and flu in last 30 days were reported in women and children as they spent a lot of time in the house. 22.75 % of women and 32 % of children were found having cough in last 30 days (Figure11) while 12.75 % of women and 26.5 % of children were reported having flu in last 30 days (Figure12) stating that in both the cases children were more prone to disease in comparison to the women. When asked about the direct effect of smoke from chulha to the women, a majority of women agreed of having eye irritation, watering eyes and breathlessness while some did not report any effect as they were habitual of this. 72 % of women reported of having eye irritation, 86.5 % watery eyes and 64 % breathlessness (Figure13). Body mass index (BMI) is an indicator of short-run health and nutritional status. 7.25 % women were found severely underweight having BMI less than 16 (Figure 14). BMI of 36.75 % women was in the range16-18 which list them as underweight and about 48.5 women were categorized as normal with BMI 18-25. A small fraction of surveyed females was found overweight (BMI 26-30). Most of the underweight and severely underweight women were the representatives of poor and BPL income brackets. Duflo *et al* (2008) also reported low BMI in females of rural Orissa.

#### Conclusion:

The present study shows the determinants of indoor air pollution in western Uttar Pradesh using data from two districts

(Muzaffarnagar and Baghpat) covering stratified sample of 433 households and 2910 individuals from four villages (Bhadal, Lohadda, Kukra, Bajitpur).

Questionnaire data collected during the study included the following information-

1. Socio-economic conditions
2. Kitchen and household characteristics
3. Fuel characteristics and
4. Health characteristics

The results from the survey suggested that about 48 percent of household have only traditional stove to cook. In the other household having cleaner fuel stove, priority is given to traditional one and thus biofuels is used by almost all of them. The adversity faced by the rural women to access cooking fuel was very high. About 44.5 tones of biofuels are used per day and 16,250.6 tones per year for cooking and heating purposes. The study revealed that about 67.75% of households get their fuel from own land & livestock, whereas 32.25 % purchase or mostly gather fuel from other's field. This indicates that households are switching to lower grade fuel wood viz., twigs, thin branches, rots of plants etc. This may cause more health problems. A lot of time and efforts of women and children are required for collecting fuel wood. Approximately 101 hours per month are required for gathering fuel wood. Generally women and children are involved in collection and transportation of fuel wood. This would mean children missing school days and less time is left for adult women to attend other household work or self fulfillment or leisure. The use of commercial fuel like LPG and electric heaters are rarely used in the house and the other commercial fuel like kerosene is only used for the igniting purpose as it is not easily available to them. The health impacts of the use of bio fuel are quite high for children which spent a lot of time around their mother. A high majority of women reported to have eye irritation, water in eyes and breathlessness while working on a traditional stove. BMI of 36.75 percent women was found underweight and 7.25 percent women were found severely underweight. The adversity faced by the women and children in the village due to biomass fuel can be reduced by increasing female literacy and economic conditions. Almost all respiratory and eye diseases are due to burning of biomass fuel. There may be other reasons also, but a large proportion is attributable to this cause. Much of the adversity of women and children and expenditure of fuels can be avoided by proper planning and policies. Even if these losses are reduced to some fractions, that can improve women welfare. Children will not have to miss their school for fuel collection and transportation. Thus, inadequate supply of clean fuel in the rural area causes indoor air pollution due to bio fuels which is a major source of hardship to women, ill- health, economic and education loss. Action oriented programs should be implemented. The problem of indoor air pollution in the surveyed area will not be solved unless their economies are sufficiently developed.

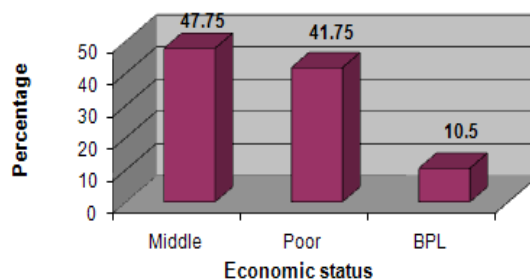


Figure 1. Economic status in selected rural area

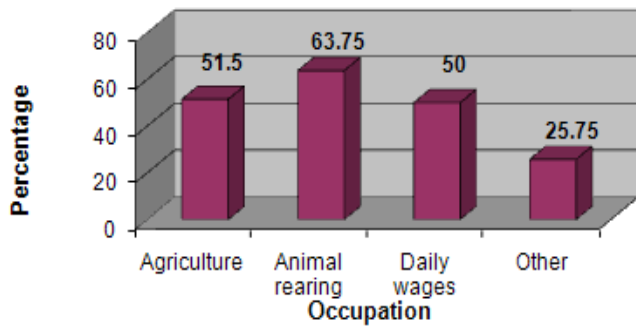


Figure 2. Occupation in selected rural area

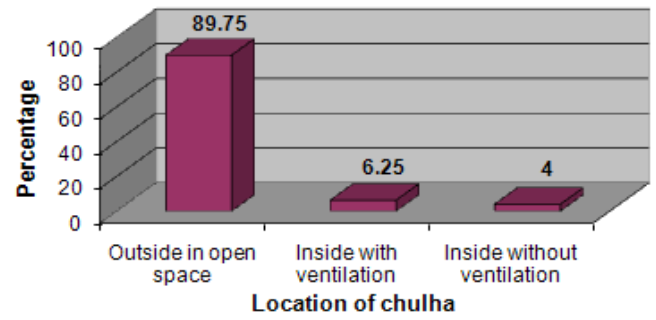


Figure 7. Location of chulha in household

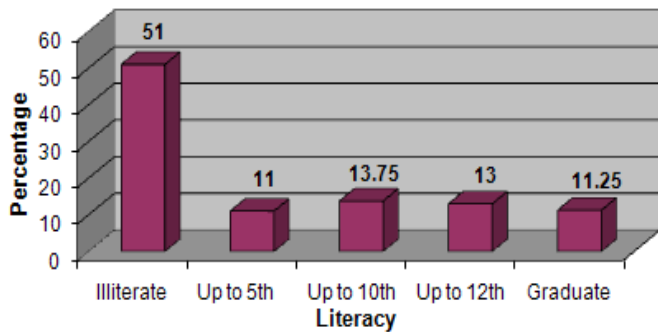


Figure 3. Literacy in selected rural area

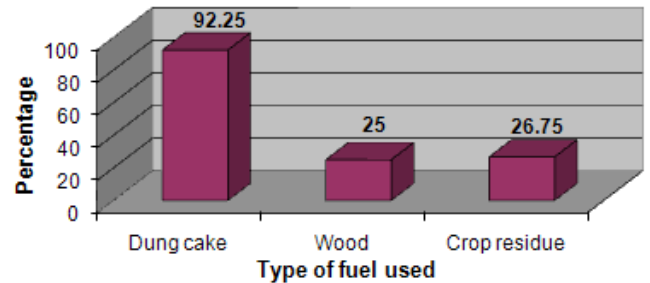


Figure 8. Different types of fuel used in the sampled area

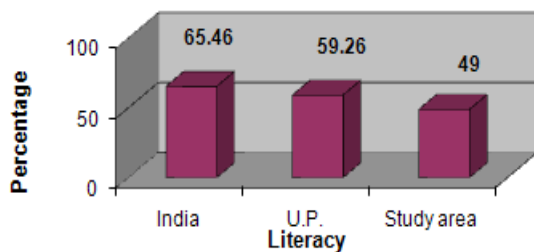


Figure 4. Literacy of the sample and comparison with Census

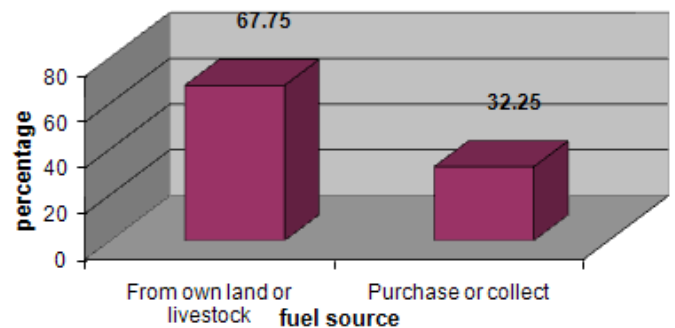


Figure 9. Fuel source in selected rural area

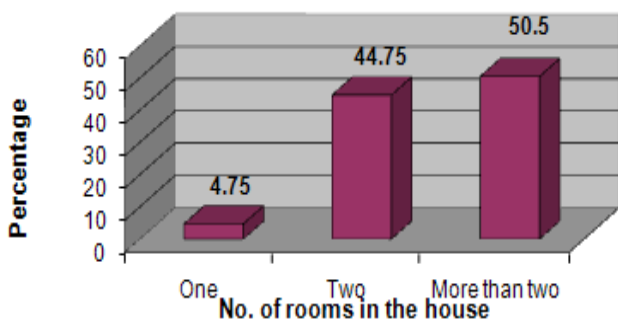


Figure 5. No. of rooms in the selected households

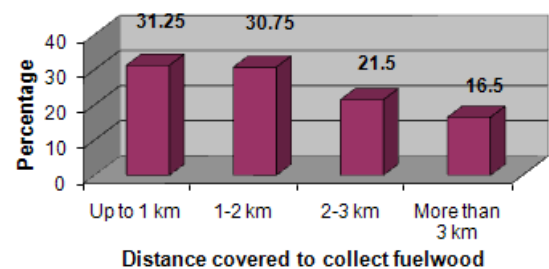


Figure 10. Distance covered by the villagers to collect fuelwood

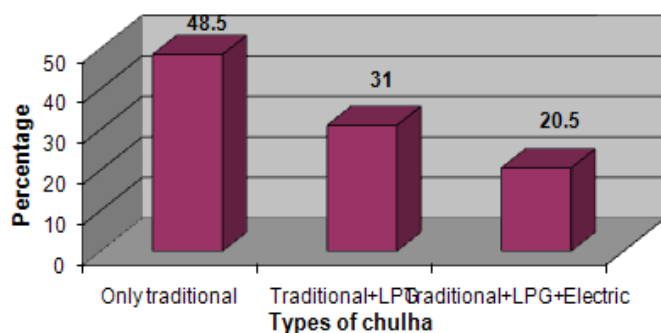


Figure 6. Types of chulha used by household

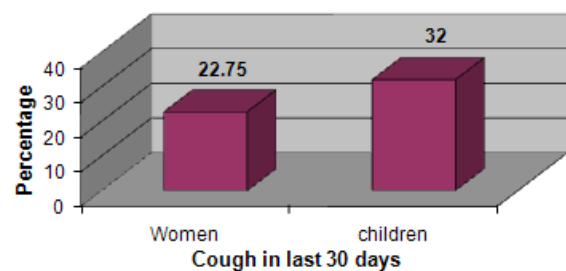


Figure 11. Cough reported in women and children (last 30 days)

**Table 1: Number of households and villages selected**

	District Bagpat			District Muzaffarnagar			Total
	Bhadal	Lohadda	All	Kukra	Bajitpur	All	
No. of household	1126	1051	2177	1160	944	2104	4281
Household covered	114	110	224	109	100	209	433
Total population	5647	5102	10749	7550	5658	13208	23957
Individuals covered	725	658	1383	903	624	1527	2910

**Table 2. Socio-economic conditions of the sampled households**

	Bhadal	Lohadda	Kukra	Bajitpur	Total
Economic status (%)					
Middle	45	50	49	47	47.75
Poor	43	42	41	41	41.75
BPL	12	8	10	12	10.5
Occupation (%)					
Agriculture	42	63	55	46	51.5
Animal rearing	61	65	70	59	63.75
Daily wages	56	49	43	52	50
Other	20	28	31	24	25.75
Literacy in women (%)					
Illiterate	48	52	50	54	51
Up to 5 <sup>th</sup>	13	7	16	8	11
Up to 10 <sup>th</sup>	21	12	9	13	13.75
Up to 12 <sup>th</sup>	10	16	11	15	13
Graduate and above	8	13	14	10	11.25

**Table 3. Household and kitchen characteristics of sampled households**

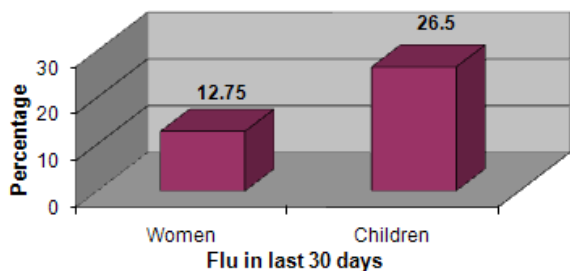
	Bhadal	Lohadda	Kukra	Bajitpur	Total
No. of rooms in the house (%)					
One	4	6	4	5	4.75
Two	47	50	43	39	44.75
More than two	49	44	53	56	50.5
Type of chulha (%)					
Only traditional	56	45	42	51	48.5
Traditional+LPG	24	32	40	28	31
Traditional+LPG+Electric	20	23	18	21	20.5
Location of chulha (%)					
Outside in open space	90	82	95	92	89.75
Inside with ventilation	8	10	4	3	6.25
Inside without ventilation	2	8	1	5	4

**Table 4. Fuel characteristics of sampled households**

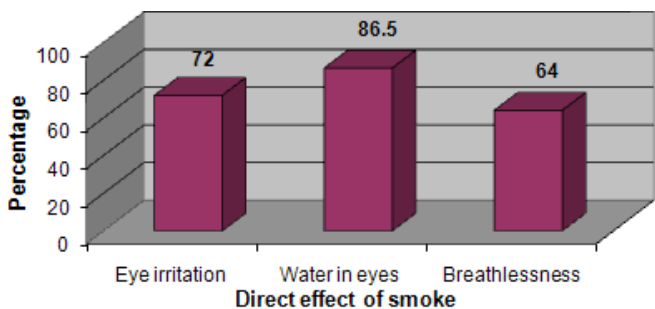
	Bhadal	Lohadda	Kukra	Bajitpur	Total
Fuel used for traditional stove (%)					
Dung cake	99	81	92	97	92.25
Wood	24	21	30	25	25
Crop residue	20	31	27	29	26.75
Fuel source for traditional stove (%)					
From own land or livestock	64	78	69	60	67.75
Purchase or collect	36	22	31	40	32.25
Distance walked to collect fuelwood (%)					
Up to 1 km	28	36	41	20	31.25
1-2 km	31	32	35	25	30.75
2-3 km	22	20	15	29	21.5
More than 3 km	19	12	9	26	16.5
Average time spent per trip (hr)	3	4	3.5	3	3.37

**Table 5. Health characteristics of sampled household**

	Bhadal	Lohadda	Kukra	Bajitpur	Total
Cough in last 30 days (%)					
Women	29	25	17	20	22.75
Children	34	30	26	38	32
Flu in last 30 days (%)					
Women	16	8	12	15	12.75
Children	31	15	24	36	26.5
Direct effect of smoke to women (%)					
Eye irritation	82	56	73	77	72
Water in eyes	90	73	85	98	86.5
Breathlessness	74	61	57	64	64
Body mass index (%)					
Severely underweight	5	9	8	7	7.25
Underweight	33	41	38	35	36.75
Normal	52	43	49	50	48.5
Overweight	10	7	5	8	7.5



**Figure 12. Flu reported in women and children (last 30 days)**



**Figure 13. Direct effect of smoke from chulha**



**Stock of collected fuel by landless peoples from others farm**



**A small child carrying heavy load of collected fuel**



**Poor women using a traditional stove**



**A women making dung cakes**



**U-shaped stove in fixed form**

**Annexure**

Consent for interview

MY name is \_\_\_\_\_ and I am a student of Gurukul Kangri Vishwavidyalaya. I have to conduct a survey about

chulha used in the village and its health impact on women and children. I would very much appreciate your participation in this survey. I would like to ask you some questions about your household. It will take about 20 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?

Date \_\_\_\_\_

### Questionnaires

#### Demographic information

1. Name of head of family or respondent \_\_\_\_\_

2. Name of village/ district \_\_\_\_\_

3. What is your economic status?

- Rich \_\_\_\_\_
- Middle \_\_\_\_\_
- Poor \_\_\_\_\_
- BPL \_\_\_\_\_

4. What is your family occupation? \_\_\_\_\_

5. No. of family members.

- Adult- Male \_\_\_\_\_  
Female \_\_\_\_\_
- Children- Male \_\_\_\_\_  
Female \_\_\_\_\_

6. Age, height and weight of females in the family.

S.No.	Age	Weight	Height
1.			
2.			
3.			
4.			
5.			

7. Literacy in women in the family.

- Illiterate \_\_\_\_\_
- Up to 5<sup>th</sup> \_\_\_\_\_
- Up to 10<sup>th</sup> \_\_\_\_\_
- Up to 12<sup>th</sup> \_\_\_\_\_
- Graduate \_\_\_\_\_

8. Does any women from your family work outside?

Yes or no

If yes in which sector \_\_\_\_\_

9. Do you own any poultry or livestock?

Kitchen and chulha characteristics

10. Which type of chulha do you have?

- Traditional \_\_\_\_\_
- LPG \_\_\_\_\_
- Electric \_\_\_\_\_
- Kerosene \_\_\_\_\_
- Biogas \_\_\_\_\_

11. Material of chulha.

- Brick \_\_\_\_\_
- Mud \_\_\_\_\_
- Other \_\_\_\_\_

12. Height of chulha in cm \_\_\_\_\_

13. No. of rooms in the house \_\_\_\_\_

14. Location of chulha.

- Separate and outside \_\_\_\_\_
- Inside with ventilation \_\_\_\_\_
- Inside without ventilation \_\_\_\_\_

#### Fuel characteristics

15. Which type of fuel do you use for traditional stove?

- Cow dung \_\_\_\_\_
- Wood \_\_\_\_\_
- Crop residue \_\_\_\_\_
- Other \_\_\_\_\_

16. What type of fuel is used for heating indoors?

- Electricity \_\_\_\_\_
- Cow dung \_\_\_\_\_
- Wood \_\_\_\_\_
- Crop residue \_\_\_\_\_
- Other \_\_\_\_\_

17. What is the source of lighting in your house?

- Electricity \_\_\_\_\_
- Kerosene \_\_\_\_\_
- Other \_\_\_\_\_

18. Source of fuel-

- From own land or livestock \_\_\_\_\_
- Purchase \_\_\_\_\_
- If purchased, how much does it cost per day \_\_\_\_\_
- If collected, how much time is spent in collecting \_\_\_\_\_

19. Km range for collecting the fuel \_\_\_\_\_

20. How many no. of meals do you cook per day \_\_\_\_\_

#### Health characteristics

21. Is there any women or children suffering from cough and flu or has suffered in last 30 days? Yes or no

If yes,

	Cough	Flu
No. of women		
No. of children		

22. What are the direct effects of smoke which women usually face while cooking on traditional stoves?

- Eye irritation \_\_\_\_\_
- Redness in eyes \_\_\_\_\_
- Breathlessness \_\_\_\_\_
- Others \_\_\_\_\_

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