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Household Fuel Use, Indoor Air Pollution and Vulnerability of Women to Its Exposure

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Abstract:
The burning of solid fuels indoors in an open fire or traditional cooking stoves (chulhas) causes indoor air pollution. Indoor air pollution resulting from these fuels is a potentially large health threat in India and is considered a major risk factor for respiratory disease, lung cancer as well as cardiovascular and other illnesses. This study reports the results of a primary survey of household fuel use and the vulnerability of women to its exposure among 85 households in Chennai city. The study found that though women are more vulnerable to indoor air pollution exposure than any other member in the family; there are differences in their vulnerability level. It is the poor and the lower income women who are most vulnerable to indoor air pollution. Not only do they live in sub-standard housing with poor environmental conditions, because of their economic backwardness they are not able to afford cleaner fuels and have to rely on solid fuels. Most of them reasoned that they did not have the financial means to use cleaner or higher grade fuels and that they have to endure the smoke emitted from cooking. And the study also found poor awareness and knowledge about indoor air pollution exposure from household fuel use. Most of the time they ignore their health issues and they do not readily attribute any illnesses to the type of fuels they burn or the stove they use. They generally bear the discomforts of indoor air pollution as a 'fact of life'.

Key words: *Indoor Air Pollution, Solid Fuels, Health, Vulnerability, Women*

1. Introduction

It has been estimated that more than half of the world's population, and up to 95 per cent of the population in low income countries still relies on solid fuels, including firewood and other biomass fuels, to meet basic energy needs (Smith et al., 2004; Duflo et al., 2008). The smoke generated by burning of these fuels contains large number of toxic pollutants and the use of these fuels indoor in open fires or unvented stoves leads to levels of indoor air pollution many times higher than acceptable international standards[i]. A 2012 World Health Organization (WHO) study found that 3.5 million people die early annually from indoor air pollution and in the words of Maria Neira, the WHO's director of public health and environment, "the problem has been underestimated in the past". Most people are aware that outdoor air pollution can damage their health but not many are aware that indoor air pollution can also have significant health effects. According to the World Health Report (2002), indoor air pollution is responsible for 2.7 per cent of the global burden of disease. Though there are many sources of indoor air pollution, the four main principal sources are: combustion, building material, ground under the building and bio-aerosols. On the whole, exposure to indoor air pollution is determined by the concentrations of pollutants in the indoor environments, and most importantly, the time spent by individuals in the polluted environments. In developing countries the most important indoor air pollutants are the combustion products of unprocessed solid fuels used by the poor urban and rural households for cooking and heating. Typically burned in open fires or low efficiency stoves with inadequate ventilation, the smoke emitted contains large quantities of harmful pollutants, with serious health consequences for those exposed, particularly women involved in cooking and young children spending time around their mothers. In fact, the use of solid fuels for cooking and heating is likely to be the largest source of indoor air pollution on a global scale. Almost one billion people, mostly women and children, are exposed to levels of indoor air pollution that exceed the World Health Organization guidelines[ii] and the problem of indoor air pollution far outweighs the ambient air pollution. Various studies from countries in Asia and Africa have shown that indoor air pollution levels in households relying on biomass fuels (agricultural residues, dung, straw, wood) or coal are extremely high, for example, typical 24 hour mean levels for PM_{10} in homes using biomass fuels are around 1000 $\mu g/m^3$, compared to the current limit of 150 $\mu g/m^3$ set by the United States Environmental Protection Agency. Thus the typical concentrations of indoor air pollutants in these countries exceed generally accepted guideline limits many times over. And indoor air pollution associated with combustion of solid fuels in households of developing countries is now recognised as a major source of health risks and has gained serious attention worldwide. It has become a major topic in environmental research and health.

2. Health Effects of Exposure to Solid Fuel Smoke

In developing countries indoor air pollution emitted from household use of traditional fuels and cooking stoves is an important cause of morbidity and mortality (Ezzati et al., 2002). Solid fuels burned in traditional stoves often result in inefficient combustion, with less than 80-90 per cent conversion of fuel carbon into carbon dioxide (CO_2). Indoor smoke resulting from burning of solid fuels contains a range of health damaging pollutants and some of the most important ones are particles (PM_{10} and $PM_{2.5}$), carbon monoxide, nitrous oxides, sulphur oxides, formaldehyde, and polycyclic organic matter.[iii]

Evidence on the health effects of indoor air pollution has grown in the last few decades and several studies have now conclusively established relationship between exposure to indoor pollution and some significant health risks. It has been estimated that exposures to the combustion products of household use of solid fuels are responsible for the majority of non-smoking human exposures to particulates and other major pollutants (Smith, 1987, 1993). Smith K et al., (2004) observed that the most common health problems associated with exposure to indoor air pollution include - acute lower respiratory infections (pneumonia) in children, chronic obstructive pulmonary disease, and to a lesser extent, lung cancer. There is also emerging evidence linking indoor air pollution with tuberculosis, perinatal mortality (stillbirths and deaths in the first week of life), low birth weight, asthma, cancer of the upper way, cataracts, etc.[iv] According to Murray and Lopez (1996), indoor smoke is a major cause of acute respiratory infections (ARI) and is the most important cause of death for young children in developing countries. Acute respiratory infection accounts for about one-eighth of the disease burden in India and it is estimated that about 400,000 to 550,000 premature deaths occur annually from indoor air pollution exposures to women and children under five[v]. The recent global comparative risk assessment organised by WHO calculated that solid fuel use was responsible for almost 2 million deaths and 2.7 per cent of the global burden of disease in 2004 (Global Health Risks: Mortality and burden of disease attributable to selected major risks, WHO).

3. Gender Differences in Exposure to Solid Fuel smoke

Specifically, indoor air pollution affects women and small children far more than any other section of society. In developing countries cooking is the preserve of women and women typically spend three to seven hours per day by the fire, exposed to more pollutants than even industrial workers in extremely polluted environments, often with young children nearby. Illnesses caused by indoor smoke include acute respiratory infection[vi], asthma, tuberculosis, low birth weight and infant mortality and cataracts[vii]. A child exposed to indoor smoke is two to three times more likely to contract acute lower respiratory infection (ALRI) and women who cook on solid fuels are up to four times more likely to suffer from chronic obstructive pulmonary disease (COPD)[viii], such as chronic bronchitis. Lung cancer in China has been directly linked to use of coal burning stoves. Various studies have shown that in developing country men typically spend less time in the kitchen area compared to women[ix] and consequently women had much higher levels of exposure than men. A DFID-sponsored study concluded that 'the burden of biomass fuel use is a major aspect of most poor women's lives. It absorbs large amounts of time in heavy work; it can have negative effects on health, and, although this problem has been recognised for 30 years, very little has been done about it'[x].

4. Research Problem

Use of biomass fuels in household for cooking and heating is widespread in India and it has been estimated that indoor air pollution resulting from the use of these biomass fuels (firewood, crop residue, coal, animal dung, etc.) are claiming a shocking half million lives in India every year, and most of whom are women and children (see WHO Report). Compared to other countries, India has the largest burden of disease due to the use of poor quality household fuels and 28 per cent of all deaths due to indoor air pollution in developing countries occur in India[xi] (Smith and Mehta 2003). In India, exposure to indoor air pollution is responsible for a high degree of respiratory morbidity and mortality among the poorest and most vulnerable sections of the society[xii] and according to the WHO, India accounts for 80 per cent of the 0.6 million premature deaths that occur in South-east Asia annually due to indoor air pollution exposure.

The serious concern over indoor air pollution is due to the fact that the pollutants are not easily dispersed or diluted as outdoor pollutants and people who may be exposed to indoor air pollutants for the longest period of time are often those most susceptible to the effects of indoor air pollution. In India, it is generally women (or girls) who take the responsibility for tending the fire and cooking and who inhale larger concentration of pollutants over longer periods (Singh and Parveen 2010). It has been estimated that about half a million women and children die every year from indoor air pollution (WHO 2005). In India, indoor air pollution caused by household fuel use is a significant public health concern and control of indoor air pollution has become very crucial and requires immediate government attention. Though it may be difficult to quantify the precise mechanism of how indoor air pollution exposure causes diseases, what is known is that small particles and several other pollutants contained in indoor smoke cause inflammation of the airways and lungs and impairs the immune response. Given this background, an attempt has been made in this study to understand what type of household use solid fuels and the vulnerability of women to its exposure and suggesting suitable measures for its intervention.

5. Objectives of the study

The specific objectives of the study are:

- To study what type of household use traditional fuels and stoves.
- To determine the level of awareness about indoor air pollution.
- To assess the vulnerability of women to indoor air pollution from household fuel use
- To suggest suitable measures and policy suggestions to reduce indoor air pollution

6. Materials and Methods

To study the above mentioned objectives, primary data collected through household surveys with the help of questionnaire interviews have been used. For the study, 85 women respondents belonging to different income groups - 8 from the highest income group (>Rs. 25,000 per month), 17 from medium income group (Rs. 15,001- 5,000 per month), 37 from low income group (Rs. 5,001-15,000 per month) and 23 from very low income group (<Rs. 5000 per month) were considered purely on a random basis. The respondents were interviewed with the help of a well structured questionnaire. The questionnaire captured information keeping in view of the objective of the study. The sample was selected from the slums or 'kuppam' area of Chennai city. The total sample size consisted of 85 women respondents in which the more affluent have access to gas and electricity while the less affluent live in traditional mud and thatch houses with no access to either gas or electricity. With the help of household information and self-reported health status, various factors that linked to the vulnerability of women to indoor air pollution were determined. They were: cooking conditions, cooking related exposures, housing and environmental conditions and health conditions. And based on these four factors, the women respondents belonging to different income groups were categorized under three (3) vulnerability levels, i.e., most vulnerable (L-1), slightly vulnerable (L-2) and least vulnerable (L-3). And in order to assess the level of awareness on indoor air pollution, women respondents were presented with a visual which contain images of three wood stoves, with varying levels of emission and asked, "Which of the following pictures look most like the condition in your kitchen? Do you believe this is harmful?" Once they had identified an image they were asked to explain the reasoning behind their choice.

7. Result and Discussion

The types of household fuel used directly impacted the amount of smoke produced and consequently the associated exposure from smoke. In the sample households, a large variety of fuels were being used for cooking purpose. These ranged from the more traditional biomass fuels like firewood, dry twigs and leaves, branches, coconut husks, cow dung, residue, etc., to those higher up of the energy ladder like kerosene and gas (LPG). As expected, families who were more affluent use gas and preferred to use gas where it was available and those who are not affluent tended to use kerosene and traditional fuels. In general, awareness of smoke related health effects was very low and despite various advantages to using LPG/gas stoves, some women raised safety concerns about it. Kerosene stoves were found in almost all the houses and though there were several disadvantages to using kerosene stoves none of the users raised safety concerns. This could be because of the cheaper cost and easy availability. The government subsidizes the cost of kerosene and is distributed through the public distribution shop run by the government. However, one interesting finding is that most houses have provisions for firewood/ chulha and even if they have the options of not using it some of the women still use traditional stoves for their cooking. In certain cases this is to take advantage of the abundant residual fuel available during a particular time or season. But in most cases it is because of the gross lack of awareness about the health effects of household fuel use. And those households that rely on wood stoves were using not only firewood, but also whatever scrap material they could find. Quite literally, any biomass matter that burns are used, for example, branches, firewood, dung, stray branches, twigs, coconut husks, etc. The table below summarizes the various fuel types used among the respondents. And as can be seen various types of fuels were used by the respondents and only 17.65 per cent of the respondents use LPG/gas. These are the relatively affluent households. And most of the respondents (42.35 per cent) still rely on traditional fuels and 28.24 per cent reported using kerosene. The study also noticed that there are some households that use both kerosene and traditional stoves simultaneously. This could be due to the fact that for those households that rely on firewood kerosene is an alternative when they do not have ready access to firewood. At the same time, for those households that primarily use kerosene, they tend to use firewood when there is a heavy cooking load. Though kerosene is often advocated as a cleaner alternative to traditional fuels, some kerosene-using devices emit substantial amounts of fine particulates, carbon monoxide (CO), nitric oxides (NOx), and sulphur dioxide (SO_2). Studies of kerosene used for cooking or lighting provide some evidence that emissions may impair lung function and increase infectious illness (including tuberculosis), asthma, and cancer risks. However, there are only a few studies and most of the time the results are inconsistent. Nevertheless, well-documented kerosene hazards are poisonings, fires and explosions and less investigated are exposures to and risks from kerosene's combustion products[xiii].

Fuel type	No: of households
LPG/Gas	17.65
Kerosene	28.24
Traditional fuels	42.35
TOTAL	100.0

Table 1: Distribution of Household Fuel Use (percentage)
Source: Based on Primary data

In general, women are more vulnerable to environmental hazards than men as a result of biological differences as well as gender role determined by social, economic and political structures of the society. Of the 85 women interviewed, most of them focussed on the immediate physical discomforts of indoor pollutants rather than the health risks. Women breathe in the air that is heavily polluted day in and day out which is hazardous to health. As such the health conditions of the women (instant effects, short term problems and specific diseases associated with indoor air pollution) were also taken into consideration while discussing the vulnerability of women. During household survey, it was observed that the type of kitchen or place of cooking, type of fuel used and the time spent for kitchen work carries the biggest risk to women's health. In any household, generally it is the women or girls who take the responsibility of household chores including cooking and this mean a consistent and long period of exposure to

pollutants. Hence it is not a wonder that women's vulnerability to indoor air pollution is greatly determined by their cooking conditions, i.e., type of fuel used for cooking, place of cooking, i.e., no separate kitchen or cooking in a small sized kitchen with poor ventilation (<20 sq. ft.), and the time taken for kitchen work (>5 h/day) and cooking related exposures like smoke from the fuel (>2 h/day), heat and vapours (>1 h/day) and the prevalence of smoke in cooking area and inside the whole house (>1 h/day). Since indoor air pollution is the most direct physical health risk, it has been noticed that housing conditions and environments like the type of house (kutcha/semi pucca houses), number of people in the house or crowding in the house (i.e., living in only one room, average sleeping floor space (<30 sq. feet), good air ventilation, etc., and the health status or conditions or of women also determines women's vulnerability to indoor air pollution.

Income Group	No: of respondents	Vulnerability Assessment Factors				Exposure to no: of cooking related risk factor	Average	Vulnerability level
		1	2	3	4			
High	8	-	-	-	25.0	1	6.25	L-3
Medium	17	-	76.47	23.52	17.64	3	29.40	L-2
Low	37	40.54	75.67	24.32	21.62	4	40.53	L-1
Very low	23	91.30	13.04	86.95	30.43	4	55.43	L-1
Total	**85**							

Table 2: Assessment of Vulnerability of Women due to Cooking Conditions (percentage)
** Vulnerability assessment factors: 1 = use of solid fuels/chulhas, 2 = cooking in a multipurpose room, 3 = cooking in a small-sized kitchen, 4 = long duration of kitchen work: Vulnerability levels: (L-3) least vulnerable; (L-2) slightly vulnerable; (L-1) most vulnerable.*
Source: Based on Primary Data

Looking at the Table, it can be noticed that there is fuel transition as the household moves from poor to wealthy. And this means the vulnerability of women increases with the increase in the use of solid fuels/chulhas, cooking in a multipurpose room, cooking in a small sized kitchen and long hours of kitchen work. The more affluent or those in higher income group using LPG/gas stoves, while the lower income group uses kerosene and firewood. Almost all the households with very low income group reported by using traditional fuels (91.30 percent). In many households, kitchens were usually located outside the house and made of makeshift materials like coconut leaves, gunny bags, etc. These detached kitchens also varied according to the affluent levels of the household and for those households that have got indoor kitchen facilities, the majority of them is poorly lit and poorly ventilated. In poor households, cooking is done in their living quarters, sometimes separated by a half wall and for the women in these households, they are worst affected by the smoke since they not only cooked under one roof and used all sorts of scrap materials as fuel but their cooking conditions increase the risk of inhaling harmful smoke, gases and particulates. Most of these poor women burn the solid fuels in chulhas or mud stove without a chimney or appropriate ventilation for the cooking smoke to escape. The solid fuels combustion in unvented stoves generates toxic/hazardous pollutants which are then dispersed in the small multipurpose room and filling the entire house. And because of the lack of proper ventilation the smokes get trapped inside the house, thus exposing other family members as well. At the time of the survey, it has been noticed that most of the women respondents' spent long hours inside the house doing not only cooking for the family but other household chores. Hence, their exposure to smoke pollutants is much higher than any other member in the family, making them more vulnerable.

Income Group	No: of respondents	Vulnerability Assessment Factors			Exposure to no: of cooking related risk factor	Average	Vulnerability level
		1	2	3			
High	8	-	37.5	-	1	12.5	L-3
Medium	17	11.76	58.82	5.88	3	25.48	L-2
Low	37	89.18	91.89	43.24	3	74.77	L-1
Very low	23	95.18	100.0	56.52	3	84.05	L-1
Total	**85**						

Table 3: Assessment of Vulnerability of Women due to Cooking Related Exposures (percentage)
** Vulnerability assessment factors: 1 = exposure to smoke (>2 h/per day), 2 = exposure to heat (>1h/per day), 3 = prevalence of smoke in the kitchen/house (>1h/per day); Vulnerability levels: (L-3) least vulnerable; (L-2) slightly vulnerable; (L-1) most vulnerable.*
Source: Based on Primary Data

Household fuel use is the main source of indoor air pollution. The composition of smoke produced by cooking stoves depends on fuel quality or stove design. Smoke is the result of the incomplete combustion of fuel. On a typical three stone wood-fired stove about 18 per cent of the energy goes into the pot, 8 per cent into the smoke and 74 per cent is waste heat[xiv]. The pollutants from the smoke make lungs vulnerable to disorders such as acute lower respiratory infections, chronic obstructive pulmonary diseases, asthma, tuberculosis, low birth weight, infant mortality, etc. Exposure to smoke, fire, high temperatures and pollutants effects women far more than any other household members because women typically spend long hours in the kitchen before the fire. Exposure to high temperatures results in health problems such as heat cramps, heat exhaustion, heat strokes, etc. Table 3 shows

that higher percentage of poor, lower income women reported (more than 80 per cent) of being exposed to smoke and heat. This is because most of them used solid fuels/chulhas for cooking food. Inefficient cook stoves gives less heat and more smoke and because of that woman had to devote long hours in the cooking place before the fire. The smoke remains inside the room for longer duration due to inappropriate ventilation and the sub-standard material used for the construction of their homes absorbs the smoke and heat for longer duration, thus increasing the time of exposure to all the toxic pollutants.

Income Group	No: of respondents	Vulnerability Assessment Factors				Exposure to no: of cooking related risk factor	Average	Vulnerability level
		1	2	3	4			
High	8	-	-	-	-	-	-	-
Medium	17	-	70.58	64.70	88.23	3	55.88	L-2
Low	37	40.54	89.18	100.0	97.29	4	81.75	L-1
Very low	23	100.0	95.65	100.0	95.65	4	97.83	L-1
Total	85							

Table 4: Assessment of Vulnerability of Women due to Housing/Environmental Conditions (percentage)
** Vulnerability assessment factors: 1 = kutcha/semi pucca houses, 2 = only one room house, 3 = sleeping floor space (<30 sq ft), 4 = poor/no ventilation in the house; Vulnerability levels: (L-3) least vulnerable; (L-2) slightly vulnerable; (L-1) most vulnerable.*
Source: Based on Primary Data

One important factor that aggravates indoor air pollution and increase the vulnerability of women to indoor pollutants exposure is the housing environments. The housing environment is a key setting with impacts on human health. It has been found that urban residents typically spend more than 80 per cent of their time in the indoor home environment. For this reason housing factors such as temperature, humidity and ventilation, overcrowding, affordability and fuel use significantly contribute to health and well-being. As has been observed in the field study most of the respondents' house are either kutcha or semi-pucca house, i.e., made of thatched, brick, tin sheets, polythene, etc. The kitchen is the neglected part and usually located outside the house. This detached kitchen is an extension of the house built with makeshift materials with sometimes one to three sides open. For kitchens with all four walls, there was sometimes a small opening, which served as a window. However, the stove usually rested in a corner of the kitchen away from the window. The results presented in Table 4 reveals that it was the lower income women (44 to 78 per cent) who were living in sub-standard dwellings and had to bear the impact of it. Not just because of the sub-standard dwelling, indoor air pollution can also happen when there is inadequate ventilation and high occupant densities per m^2 area. Simply put, indoor over-crowding or too many people living in one house can also results in indoor air pollution. As seen from the table, crowded-cramped conditions were observed in poorer homes. Though most of the respondents live in overcrowded homes and insufficient living space, the situation was much more worser among the low income households. Most of the low income respondents were living in a cramped, confined and poorly ventilated house. It has been well documented that indoor air quality is greatly influenced by the characteristics of the building as well as the habits of the residents. High occupancy can lead to high carbon dioxide (CO_2) concentrations[xv] , growth of molds, fungi and bacteria and accumulation of pollutants like CO, TVOC and suspended particulate matter. Communicable diseases like pneumonia, tuberculosis, skin infections, etc., is strongly associated with it and can be easily transmitted from one person to another due to crowding and limited ventilation. As seen in Table 2 most of the lower income household burn solid fuels in an unvented stoves/chulhas where incomplete combustion resulted in substantial emissions of pollutants. In general, a healthy indoor environment is achieved through balancing temperature, relative humidity and ventilation. An imbalance of one factor alone can have an impact on the indoor environment to the detriment of the residents/occupants. Hence, the most effective way to reduce indoor air pollution is by having proper ventilation in the house. As has been observed, all the high income respondents in the study were having adequate ventilation in their homes. It was only the low income respondents who were the main sufferers. It has been said that the burden of indoor air pollution is closely linked to poverty and in the present study as well it has been found that it is the economically backward households who bears the impact of indoor air pollution the most. They live in sub-standard housing, cramped and overcrowded with little or no ventilation, no proper place for cooking and insufficient living space.

Income Group	No: of respondents	Vulnerability Assessment Factors			Exposure to no: of health related risk factor	Average	Vulnerability level
		1	**2**	**3**			
High	8	-	37.5	-	1	12.5	L-3
Medium	17	35.29	41.17	17.64	3	31.37	L-2
Low	37	81.08	89.18	78.37	3	82.87	L-1
Very low	23	95.65	78.26	91.30	3	88.40	L-1
Total	**85**						

Table 5: Assessment of Vulnerability of Women due to Health Conditions (percentage)
** Vulnerability assessment factors: 1 = instant effects(cough, eye, nose and throat irritation, skin burns, watering of eyes, low visibility, nausea, fatigue, sinus congestion), 2 = short term problems(headache, backache, skin irritation, dizziness, sneezing), 3 = specific diseases associated with indoor air pollution(breathlessness, chest discomfort, asthma, low birth weight); Vulnerability levels: (L-3) least vulnerable; (L-2) slightly vulnerable; (L-1) most vulnerable.*

Source: Based on Primary Data

Burning of solid fuels in inefficient stoves in a poorly ventilated area releases pollutants that pose great health risk to women. Millions of women in India are confronted with a host of health issues every day of their lives. Indoor air pollution, primarily from using unprocessed fuels on traditional stoves, is one of the leading causes of acute respiratory infections in women and children[xvi]. Inefficient stove releases toxic pollutants. Some of the most important ones are particles (PM_{10} and $PM_{2.5}$), carbon monoxide, nitrous oxides, sulphur oxides, formaldehyde and polycyclic organic matter[xvii]. There are wide ranging health effects arising from inhaling contaminated indoor air. Particles with diameter below 10 µ and particularly these less than 2.5 µ are small enough to penetrate deeply into the lungs and have the greatest potential for damaging health (USEPA, 1997). Indoor air pollution mostly affects health through inhalation, but can also affect the eyes through contact with smoke. All women interviewed complained and reported occurrence of physical discomforts of smoke exposure, for e.g., coughing, eye, nose and throat irritation, low visibility, headache, back pain, dizziness and nausea, sneezing, etc. Among the respondents, women from poor households felt a strong sense of inadequacy. Comments like "*what can we do*?" "*we are poor people*" "*we are uneducated and do not understand so much*" were frequently heard in response to questions about indoor smoke and pollution. The table above shows that it was the lower income women living in sub-standard dwellings that suffered the most from all the health problems (80 to 90 per cent) associated to indoor air pollution.

The analysis presented from Table 2 to Table 5 showed that the degree of vulnerability varies among the sample households. So, to present an overall picture, the total average of 4 subheads was worked out and a maximum (>60 per cent), medium (20-60 per cent) and minimum (<20 per cent) was assigned to work out the differential vulnerability. Table 6 presented the analysis and it was observed that the very low and low income women respondents came under most vulnerable category (81.18 and 69.98 per cent being affected), medium income group came under moderately vulnerable (35.53 per cent being affected) and the high income group came under least vulnerable category (7.81 per cent being affected).Thus, it can be concluded that it is the poor household women who are most vulnerable to indoor air pollution.

Income Group	No: of respondents	Cooking conditions	Cooking related exposures	Housing conditions	Health conditions	Total Average	Vulnerability level
High	8	6.25	12.5	-	12.5	7.81	L-3
Medium	17	29.40	25.48	55.88	31.37	35.53	L-2
Low	37	40.53	74.77	81.75	82.88	69.98	L-1
Very low	23	55.43	84.05	97.83	88.40	81.18	L-1
Total	**85**						

Table 6: Differential Vulnerability of Women to Indoor Air Pollution.(percentage)
** Vulnerability levels: (L-3) least vulnerable; (L-2) slightly vulnerable; (L-1) most vulnerable.*
Source: Based on Primary Data

8. Conclusion

One of the key findings of the study is the influence of literacy. Among the women interviewed, awareness and knowledge about indoor air pollution resulting from household solid fuel use is very poor but literate respondents have shown greater awareness and some of them even claimed that they understood more than the average person and always try to follow good health practices. Lower levels of illiteracy are a challenge for awareness. Their illiteracy makes them unaware of the ill effects of solid fuels use, importance of proper ventilation in the cooking area and in the house, uses of cleaner fuel and improved cook stoves, etc. And as for the vulnerability of women to indoor air pollution, the study concluded that an important factor that determines women's vulnerability is the economic status of the household. Household income and assets influences the households' ability to afford good quality housing, separate kitchen, access to cleaner fuels, access to proper health care services and taking time off to recuperate when sick. Field study has shown that household environmental conditions greatly prevented or had a negative impact on women's exposure to indoor air pollution. Due to the traditional beliefs and women's customary role in household activities including cooking, they spend a great deal of time inside the house and long hours near the fires/stoves inhaling large concentration of solid and gaseous toxic pollutants thus damaging their respiratory system. Unfortunately the greatest burden of health risks is very often borne by the disadvantaged in societies and the burden of indoor air pollution from solid fuel use is a major aspect of most poor women's lives. The study had shown that it is the poor and lower income women who bear most of the burden of diseases and problems associated with indoor air pollution. Not only do they reside in sub-standard housing with poor environmental conditions, because of poverty they are not able to afford cleaner fuels and have to rely on solid fuels. In poor housing conditions where rooms are small and tiny with no separate kitchen and where food is cooked in unhygienic conditions using solid fuels in unvented or open fire, pollutants exposure and effects on the health of women are likely to be significantly high and more severe.

9. Policy Suggestions

- Based on the results and findings of the study the possible policy implications that will help the policy makers in formulating policies to address the situation are as follows:

- Dissemination of information in easy to read and listen to messages. These messages should address the health risks to women and children of kitchen smoke and primary preventive measures. Also, conducting both epidemiological and ethnographic studies to further investigate the issue is equally important.
- Mass media campaigns, public lectures and door-to-door campaigns. The mass media (radio/TV) and advertising should be used to document the adverse health impact of the traditional fuels/stoves. Develop a drama series around indoor air quality. Entertainment education approaches like drama serials and television health spots can reach large audiences and play an important role in disseminating the information.
- It has been documented that as household income improves they move up the energy ladder and opt for convenient energy sources. Interventions that facilitate transitions from solid fuels to cleaner fuels should be supported. Policy interventions should address improvement of the distribution network, reduction of the upfront initial cost, provide lower size refills based on an assessment of market needs.
- The role of women remains marginalized and there is challenge to truly empower them. As a part of the developmental programmes, special programmes of government focussing on health and self awareness will help in eliminating the health problems of women in the long run and the adverse effects of indoor air pollution in the short run.
- Improved cook stoves (ICS) can significantly improve the quality of life. Government policy on cook stoves and fuels is fragmented and has had limited impact to date. Several modifications to the government's improved cook stove policy would make ICS a feasible alternative for the very poor. However the program should pay attention to area specific needs, greater coordination and extensive user participation during the design and implementation phase.

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11. Notes

- i For example, PM_{10} refers to particulate matter with a diameter of less than or equal to 10μm and these particles are widely believed to pose the greatest health problems. The United States Environmental Protection Agency (EPA) standard for an acceptable annual 24-hour average of PM_{10} is 150μg/m^3, and they state that this level should not be exceeded more than once per year. In fact, 50μg/m^3 is the accepted norm for PM_{10} (EPA, 2006). However, in households depending on solid fuels, over 24-hour period typical mean PM_{10} concentrations can exceed 2000μg/m^3, and carbon monoxide concentrations can exceed 20ppm and during actual cooking or heating, the levels of these two pollutants can exceed their 24-hour averages by an additional order of magnitude (Bruce, Perez-Padilla & Albalak, 2000). Smith (2000) reports that mean 24-hour PM_{10} concentration in solid-fuel-using households in India sometimes exceed 2000μg/m^3.
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- iv Vinod Mishra, Robert D. Retherford, Kirk R. Smith, "Effects of Cooking Smoke on Prevalence of Blindness in India," East-West Center Working Papers, July 1997, Population Series, No. 91., Wood Energy, Women and Health: A Sub-regional Training Course, FAO-RWEDP, Bangkok, March 2000.
- v Kirk R Smith,"National Burden of Disease in India from Indoor Air Pollution", National Academy of Sciences, 2000.
- vi The WHO (2002) estimates that, in terms of DALYs, 35.7 per cent of acute lower respiratory infections are caused by exposure to solid smoke. Acute lower respiratory infection, such as pneumonia, is the world's greatest killer of children under the age of five and accounts for around 2.1 million deaths annually in this age group ('Initiating an alliance for action: healthy environments for children' WHO, 2002). In the early part of the 20th century, ALRI, in the form of pneumonia, was a major cause of death in industrialized countries. It decline with improvements in housing and nutrition before the advent of vaccines and antibiotics (Smith K.et al, 'Indoor pollution in developing countries and acute lower respiratory infections in children' 2000).
- vii Hospital-based studies in India have shown an increased incidence of curtail, nuclear and mixed cataracts (Bruce N.et al 'The Health Effects of Indoor Air Pollution Exposure in Developing Countries', WHO, 2002).
- viii The WHO (2002) estimates that 22 per cent of all COPD is caused by exposure to indoor smoke from biomass fire.
- ix Vinod Mishra, "Gender Aspects of Indoor Air Pollution and Health: An Analysis of Gender Differentials in the Effect of Cooking Smoke on Acute Respiratory Infections in Children," in Gender Analysis in Health, edited by Claudia Garcia-Moreno and Rachel Snow, Geneva: World Health Organization (2001).
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- xi The NFHS – National Family Health Survey reported that 71 % of India's households and 91 % of rural households use traditional fuels – wood, dung, crop residue and charcoal, for cooking and heating needs.
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- xiv 'Energy, the environment, and Health', World Energy Assessment: Energy and the challenge of sustainability (2000).
- xv Exceeding 1000ppm as per the standards prescribed by American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).
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- xvii Ibid