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Abstract

The use of polluting fuels for cooking poses a major health burden on members of poor households in developing countries. The dependence of biomass is both a cause and consequence of poverty. Reliance on this dirty fuel for cooking can compromise health thereby hold back economic development creating vicious circle of poverty. Traditionally women take the responsibility of cooking and often they carry children on back close to warm hearth, exposed to vulnerable and hazardous pollutants. Since firewood is obtained from various sources, each source implies varied influence on the quantity and quality of fuel used. The use of different types of biomass result in different levels of indoor air pollutants causes severe health problems such as Acute Respiratory Infections, lung disease, tuberculosis, asthma, blindness and adverse pregnancy outcomes.

The present paper tries to assess the influence of the supply source of fuel woods on the fuel consumption pattern of selected households. The probability of household members affected severely by indoor air pollution will be examined. The cost of illness of households due to indoor air pollution will be analysed with the help of various socio-economic, locational and housing characteristics. The objective assessment of the damages incurred to the households using fuel wood by adopting cost of illness approach will be attempted.

Key Words: Indoor air pollution, Biomass, Health problems, Cost of illness.

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1. Introduction

Environmental quality is an important determinant of human health and longetivity of life. An ideal environment is one in which people are free from illness or disability. Environmental quality is deteriorated when human activities release substances into the atmosphere causing different types of pollution. Air pollution is one among them that is the outcome of the release of chemicals, particulate matter and poisonous gases into the atmosphere causing harm or discomfort to the humans. Indoor air pollution (IAP) is a typical form of pollution prevalent among the poor households in developing countries. IAP is caused mainly by the use of traditional fuels for cooking such as firewood, biomass and cow dung. More than half of the world's population relies on biomass to meet their cooking needs. Cooking and heating by using solid fuels leads to high levels of IAP. This indoor smoke contains a range of health-damaging pollutants including small soot or dust particles that are able to penetrate deep into the lungs. In poorly ventilated dwellings, indoor smoke exceeds the acceptable levels of outdoor air small particles by 100 fold. Exposure is particularly high among women and children, who spend more time near the domestic hearth. IAP responsible for the illness of women and children using biomass for cooking has been relatively less known and learnt.

2. Biomass Consumption for Cooking

Fuel wood is the largest source of fuel for cooking in India which accounts for about 60 per cent of the total energy consumption. Fuel wood is the superior fuel among biomass where a substantial share is contributed by twigs, fallen woods, wood shavings,

saw dust, bark and roots, crop residues and dung cake. Nevertheless, firewood would continue to be used as the least expensive fuel, consistent with the cultural patterns and living habits of people, easy to regenerate, minimum intervention for production and utilisation, socially acceptable and responsive to low inputs and low maintenance. Fuel wood consumption depends on the available alternatives of wood, user's income and opportunity cost of collector's labour time.

The production and supply of fuel wood have largely remained in the informal sector. Households obtain fuel wood from one or many sources by collection or purchase and it may be difficult to account the exact quantity of use from each source everyday (The NCAER). The total contribution of forests in meeting the fuel wood needs was 53 per cent and villagers own source (homesteads and farmlands) contributed by 26 per cent.

In Tamil Nadu, fuel wood studies revealed that about 53 per cent of the total fuel wood consumed was collected free of cost from horticultural residues, Propopis species, Acacia species and Casuarina Equsetifolia, most of which were growing in non-forest lands. In urban India, fuel consumption pattern has been changing rapidly. The share of traditional fuel in urban areas has declined from 49 per cent in 1983 to 24 per cent in 1999 due to increased accessibility to kerosene, LPG and electricity. In rural India, there has been marginal change in the fuel consumption pattern during 1981-1999. Traditional fuels still account for about 90 per cent of domestic energy (Table 1).

The energy consumption pattern in the urban and rural areas (1983-2000) demonstrates that in rural areas, fuel wood, charcoal and agricultural waste constituted a major portion of total household energy consumption (Table 2). The urban-rural energy consumption pattern for cooking illustrates that the quality of energy use in rural areas

lags far behind that of the same in urban areas. It is evident that there is a clear decline in the use of biomass and an increased diffusion of modern fuels both in the urban and rural areas. The high cost and non-availability of alternate commercial fuels have led to the continued dependence of rural households on fuel wood. Forests sustainably take the needs of its dependents by supplying dead wood and pruned wood besides twigs and small branches of non-commercial woods. People experience fuel wood scarcity switch over to alternatives such as crop residue, dung cake, leaf litter, etc, to meet their domestic fuel requirements. A lot of fuel wood is produced from trees along roads, canals, farmlands and wasteland. Fuel wood gathered is often a non-monetised commodity. Fuel wood collection by head or shoulder loads is not done from longer distance but from areas that are in the vicinity of habitation centres.

3. Supply and Demand for Fuel Wood

India is with a population of more than one billion where nearly 700 million people have no access to modern energy. Nearly 300 million people do not have access to electricity and 625 million do not have access to modern cooking fuels (Census of India, 2001). Nearly 3 billion days are spent in gathering fuels and 700 million days in processing them i.e., chopping, drying, turning, storing, stacking and handling.

Out of the total domestic energy demand, 59.2 per cent in rural areas and 35.5 per cent in urban areas is being met from fuel wood. The use of dung cake and agricultural waste as fuel is widely prevalent in rural areas while marketed firewood continues to be the main domestic fuel among poor in semi-urban and urban areas. Women and girl children are generally associated with the activities of collecting fuel wood as well as burning these fuels for cooking. A sizeable time of everyday is allocated for both

collection and cooking. Since firewood is obtained almost practically free of cost, there is no inducement for the villages to shift to other energy sources.

Consumption of fuel wood varies with availability and accessibility. It is generally a function of the cost of obtaining the fuel wood. Consumption of various cooking fuels by households and the mix of such fuels used are influenced by household income, accessibility and prices of different fuel supplies, climate, and resource endowment, size of area, household fuel preferences, social characteristics, food habits and regional cooking styles. In spite of such problems, several attempts have been made to estimate the demand for fuel wood.

Urban households can switch to modern fuels easily because of their availability. In urban areas consumption pattern of fuel are more likely to be affected by relative fuel prices (Table 3). Fuel wood is the most common cooking fuel of the poor. Poverty is the greatest barrier to reduce inequality. Fuel wood use is both a cause and a result of poverty.

4. Poverty and Biomass Use

The use of polluting fuels for cooking poses a major burden on the health of poor families, the dependence on such fuels is both a cause and a consequence of poverty as they often do not possess resources to purchase more efficient fuels and appliances. Reliance on dirty household fuels for cooking and the use of traditional and inefficient appliances can compromise health thereby hold back economic development creating vicious cycle of poverty.

Fuel gathering is frequently the women's responsibility, whereas men control the resources such as land and cash from which fuel wood comes. Hence, the problem of fuel

wood is an important gender issue. In fact, the energy planning is gender blind because it fails to recognise the role of women in meeting energy requirements. Addressing the issue of IAP resulting from burning of biomass for cooking in households is linked to achieving the Millennium Development Goals (MDGs) (2000). It is linked to reducing child mortality (Goal 4), to promoting gender equality and empowering women (Goal 3) to opening up opportunities for income generation and eradicating extreme poverty (Goal 1), and to ensuring environmental sustainability (Goal 7). World Health Organisation (WHO) suggests that the proportion of the population using solid fuels for cooking is an indicator for assessing health. Yet, the central role of household energy is not currently reflected in the political responses to achieve the Millennium Development Goals.

In urban areas there is a trend of replacing wood with either kerosene or gas especially with increase in income. Percentage share of energy expenditure in the household budget is the most important indicator for identifying poor. Low energy expenditure could mean that modern energy services are unavailable or unaffordable so that households resort to biomass free of cost. A lower share of energy expenditure in the household budget would mean that the budget share of energy tends to fall as income increase. Nearly 10-15 per cent of the total income is spent on firewood consumption among the poor in urban areas. This implies that wood users are very vulnerable to price fluctuations in firewood markets. Over all budget share of firewood using households is much lower in rural areas.

5. Health Effects of Indoor Air Pollution

The precise mechanism of how IAP causes disease is still unclear, nevertheless it is known that small particles combined with other pollutants contained in indoor smoke

cause inflammation in the respiratory system and impair the immune response. Carbon monoxide produced while cooking by using biomass results in systemic effects by reducing the oxygen-carrying capacity of the blood.

Women exposed to indoor smoke are likely to suffer three times more than Chronic Obstructive Pulmonary Disease (COPD). IAP is responsible for approximately 7 lakhs out of the 27 lakhs global deaths due to COPD. Every year, more than one million people die from lung cancer globally, and IAP is responsible for approximately 1.5 per cent of these deaths. Traditionally women take the responsibility of cooking and they spend on an average three to seven hours per day for cooking. Young children are often carried on their mother's back or kept close to the warm hearth. Consequently, infants breathe indoor smoke and exposed to vulnerable and hazardous pollutants. As a result, 56 per cent of all IAP deaths occur in children under five years of age.

Exposure to IAP more than doubles the risk of pneumonia and is thus responsible for more than 9 lakhs of the total 20 lakhs annual deaths due to pneumonia. IAP is the fourth-leading cause of premature death in the developing world. In India, the most important disease associated with IAP is Acute Respiratory Infections (ARI). Biomass do not posses uniform quality and it varies depend on the moisture content and the composition ranging from woody stems, barks, roots, twigs and dry leaves. The implications for the use of biomass are that it remains a dirty, massy, unhealthy fuel. Its use is very time consuming and inefficient. Therefore the impact of the use of different types of fuel wood has no uniformity on personal health.

IAP from burning solid fuels is regarded as one of the most serious environmental problems facing developing countries (Smith et al, 2000; World Bank 1992), endangering

the health of 400 to 700 million people. Cooking using biomass may result in exposure to extremely damaging toxic pollutant resulting in ambient concentrations more than 10 times the permitted level. The USA's Environmental Protection Agency (EPA) standard for an acceptable annual 24 hour average of PM_{10} is 150μg/m^3. This level should not be exceeded more than once per year. In comparison to this, Smith (2000) reports that mean 24 hour PM_{10} concentration in solid fuel using households in India some times exceed 2000 μg/m^3.

The important pollutants emitted as a result of burning biomass for cooking include carbon-monoxide, particulates, benzo(a)pyrena, formaldehyde, oxides of nitrogen and sulphur dioxide. Different biomass emits different levels of pollutions. It is estimated that every kilograms of wood burnt emits 40 mg of CO_2, 2000 mg of particulates, 1 mg of benzo (a) pyrene and 200 mg of formaldehyde.

In high mortality developing countries, IAP accounts for 3.6 per cent to 3.7 per cent of Disability Adjusted Life Years (DALYs). Assessments of the impact of IAP on the health status of households in India have the burden of diseases attributable to solid fuel use have put 4 to 6 per cent of the national burden of disease. Health effects of IAP go hand-in-hand with exposure. Biomass fuels, open stoves and inadequate ventilation collectively work against the health conditions. Young children are more susceptible to adverse effects of IAP because lead content at a given blood load level will be more than adults. India is the most affected country among the five most mortality affected countries in the world due to the combustion of unclean fuels for cooking.

6. Review

There are some important studies linking biomass use, air pollution and health in rural Indian villages. According to the recent National Family Health Survey of India (Mishra et al 1997) acute respiratory infections in children (ARI) has been found as 6.6 per cent in houses using biomass. Further, many studies have been conducted with small sample sizes that do not adequately capture the influence of exposure variables on actual exposures. A study by Jyothi Parikh and others (1999) assesses exposures to respirable dusts in rural households across four districts of Tamil Nadu. Riyani (1993) discusses the concentration of Total Suspended Particles (TSP) during cooking in the houses of Eastern Ahmedabad. This study concludes that houses using cattle dung, wood and other dirty fuels emit large amount of TSP. Ramakrishna (1990) estimates quantitatively the influence of several environmental and cultural characteristics on TSP exposures. Smith (1994) in his study reveals in addition to the outdoor concentrations, it can also be influenced by indoor exposure. It also states that population exposure depends on pollution concentration as well as on the number of people involved. Most of these studies try to explain the prevalence of respiratory diseases among children and women.

Estimates of the International Energy Agency (IEA, 2004) show that the number of people depends on biomass fuels for cooking and heating will increase in the future. The recent publication briefing by the Intermediate Technology Development Group (ITDG, 2002) titled ‘Smoke: the killer in the kitchen’, discusses the negative health effect of the exposure of indoor smoke on people in the developing world, especially among women and children. Despite the growing magnitude of this problem, the health impacts

of exposure to IAP have yet to take the central focus of research. Only recently the issue of IAP has come to the forefront of international concern.

The present study tries to understand the cost of illness (COI) of households due to IAP has been analysed with the help of various socio-economic, regional and housing characteristics.

7. Objectives

The main objective of the study is to assess the health impact of exposure to IAP on the households in Tamil Nadu. The supplementary objectives of the study are:

1. To assess the socio-economic conditions of households using fuel wood in Tamil Nadu.
2. To examine the health problems of households using fuel wood in the urban and rural districts of Tamil Nadu.
3. To analyse the economic impact of health damages due to indoor pollution caused by fuel wood use at the household level in Tamil Nadu.

The objectives of the present study, the researcher is to rely on primary data. A suitable research design has been framed before drawing the samples and conducting the field work. The research design is a combination of both descriptive and diagnostic methods.

Sample Design

Multi-stage sampling has been adopted as the sampling technique. The universe of the present study is the total number of households either partially or fully using fuel wood as the energy source for the purpose of cooking in Tamil Nadu. The sources of fuel wood influence the use and quality of it for cooking. Since urban dwellers use firewood

by purchasing it from market, important cities of Tamil Nadu has been listed. Likewise various districts of Tamil Nadu have been classified on the basis of forest depending households and non-forest depending households for cooking. Thus the entire universe has been classified into three segments on the basis of the accessibility to the fuel wood viz., cities, depending markets for fuel wood districts where household depending forest for cooking directly or indirectly and districts where households depending farms, backyards and non-forest commons for their fuel needs.

Total number of sample households in each category is roughly based on the size of the universe. Thus 200 households from each category totalling 600 sample respondents have been selected.

The multiple regression measures have been adopted to find the important determinants of the cost of illness due to indoor pollution.

8. Results

(i) Socio-Economic Background of Households

The fuel choice and fuel consumption pattern of households depends on their socio-economic characteristics. Hence the socio-economic background of biomass using households belonging to different geographical locations is obtained through a social survey. All the sample households use biomass for cooking. But they are distinguished on the basis of their locality and accessibility to biomass. Thus the sample households are elicited in the same proportion from urban, forest-depending and non-forest depending areas.

One out of every five respondents (20.2 per cent) is a woman. Men are the decision makers in majority of the households. More than half (54.5 per cent) of the

respondents are aged between 35 and 50 years. Most of the respondents belonging to the forest depending area is young while the respondents in non-forest depending area is relatively aged. With regard to literacy status, nearly one-fourth of the respondents are illiterates. The educational standards of the respondents reveal that 70.2 per cent of the literate respondents studied up to the high school level. Respondents in forest depending area are better educated than non-forest depending area. Three out of every four respondents (74.9 per cent) in urban area are educated up to the high school level. Out of 600, 92.2 per cent of the respondents are married. Married respondents represent the maximum in urban households. Unmarried respondents are more in households depending forest areas for fuel wood. Nine out of every ten respondents (89.5 per cent) are Hindus. The other dominant religions are Christians and Muslims who share 8.8 and 1.7 percentages of the total households.

The caste-wise classification of the respondents shows that 44.7 per cent of the sample households belong to the Backward Caste. Next to Backward Caste, Most Backward Caste households account for 34 per cent. Scheduled Caste and Scheduled Tribes are in the percentages of 15.7 and 5 respectively. Backward Class households are more in urban areas accounting for 57.5 per cent. Most Backward Class households predominate (44.5 per cent) in areas where households depend forest for fuel wood. The upper castes have an insignificant share (0.7 per cent) among the sample households.

Tamil is the mother-tongue for 89.8 per cent of the households. The average size of the household is computed as 4.38 with a minimum of 2 to a maximum of 9 members. It is found that rural households have larger family size when compared to the urban households (Table 4).

The average income of the respondent in rural area is higher (Rs.7728.25) when compared to the average income of the respondent in urban area (Rs.6249). The average monthly household income is equal to Rs.10448.56. The average monthly household income of rural areas (Rs.11520.5) is much higher than that of the same in urban households (Rs.8305.5).

(ii) Household Expenditure, Saving and Indebtedness

It is evident that expenditure categories of food, interest payments and other expenditures are the three significant items of household expenditure in the magnitude of Rs.2707.88, Rs.1283.85 and Rs.1130.42 per month respectively. It is found that the average monthly household expenditure of rural households is Rs.7076.65 in comparison with that of Rs.5681.91 in urban areas. It is found that 64 per cent of the household expenditure in urban area ranged between Rs.2500 and Rs.6500 per month (Table 5). The average monthly household expenditure of non-forest depending households is lesser than that of the forest depending households but higher than the urban households. The average savings of the households is estimated as Rs.13037.6. This is Rs.8491.5 in the case of urban households as compared to Rs.16272 of rural households.

Nearly two-thirds (65.3 per cent) of the sample households are indebted. Across the different localities, three-fourth of the households (74.5 per cent) in forest depending areas are indebted when compared to 69.5 per cent in non-forest depending areas and 52 per cent in urban areas. The socio-economic indicators of households in forest depending areas are relatively better except the high level of indebtedness.

(iii) Housing

Indebted households having debt below Rs.10,000 in urban, forest-depending and non-forest depending areas are in the percentages of 37.5, 34.3 and 51.8 respectively. It is interesting to note that 50.8 per cent of the indebted households borrowed for the purpose of meeting consumption expenditure.

Housing characteristics along with type of solid fuel use determine the exposure of indoor pollution. Out of 600 household, 72.2 per cent owned their house. The rented and leased houses are in the percentages of 25.7 and 2.2 respectively. Nearly 50 per cent of the sample households in urban areas lived in rented house. Nearly one-third (30 per cent) of the sample urban households have been living in the same house for the past 21 to 28 years. With regard to the rural households 23 per cent have been living in the present houses for the last 35 years or more. Most of the sample urban households using firewood live in single room huts without a separate kitchen facility.

With regard to the area of housing one out of every two households (46 per cent) lived in the dwelling having an area less than 500 sq.ft comprising 16 per cent in less than 250 sq.ft and 30 per cent between 250 to 500 sq.ft. On an average households depending forest for fuel wood live in bigger houses when compared to households not depending forest for fuel wood and urban households. The average housing area of urban sample households is the least when compared to the forest depending and non-forest depending households.

More than half of the total households (55.5 per cent) depending forest for fuel wood lived in the dwellings having concrete roof as compared to two-fifths (41 per cent) of the urban households. Nearly one-third of the forest depending households lived in

tiled houses. More than four-fifths (86 per cent) of the sample households are nuclear families, while the remaining 14 per cent are joint families.

(iv) Fuel Consumption Pattern

Literature on IAP in developing countries show the highest level of poverty and marginalisation associated with the worst levels of exposure to IAP. The fuel consumption pattern of the households is largely linked with their socio-economic and cultural background.

(v) Particulars of kitchen

The average size of the kitchen of the sample households is estimated as 83.60 sq.ft. More than one-third (35 per cent) of the urban households have kitchen sized 40 to 50 sq.ft. It is found that 58 per cent of the sample households have kitchen clearly separated from the rest of the house either by wall or door. The remaining 42 per cent households have no separate kitchen. The size of the kitchen is inversely related to the exposure to IAP. Nine out of every ten households depending forest for fuel wood lived in dwellings that have separate kitchen. Nearly three-fourth (71.5 per cent) of the households not depending forest for fuel wood have no separate kitchen. It is observed that dwellings with small but separated kitchen with poor ventilation cause more exposure to IAP. One-fourth (24.7 per cent) of the houses have chimney; four-fifths of the urban households do not have chimney in their kitchen, while it is the same for forest depending and non-forest depending households in the percentages of 77 and 68 respectively. It is found that 18 per cent of sample households are connected exhaust fan in their kitchen.

Most of the households cooking by using biomass are not using them alone but with a mix with either kerosene or LPG. Only 12.5 per cent of the sample households use firewood or other biomass cooking. Nearly half (49 per cent) of the total sample households take kerosene as the intermediary fuel. It is found that two-thirds of the urban sample households have kerosene and LPG as the intermediary fuel in comparison with 55.5 and 61 percentages respectively of the forest depending and non- forest depending households using kerosene alone as the intermediary fuel. Fuel wood alone used for cooking is found relatively more among households not depending forest for fuel wood. Kerosene is an important item supplied through Public Distribution System (PDS) which is being used for cooking and lighting in some of the rural households and exclusively for cooking in urban households. The average period of households using kerosene is computed as 9.43 years. It is due to more liberal supply of kerosene through PDS in rural areas in recent years that motivate them to use kerosene along with fuel wood for cooking.

Accessibility and affordability are the two important factors responsible for the selection of LPG as an intermediary fuel for cooking. Out of the total sample households 33.5 per cent (201 out of 600) were connected LPG to their household. It is the highest among urban households (54.5 per cent) when compared to 30.5 and 15.5 percentages respectively of the same in forest depending and non-forest depending households respectively. Nearly half of the total sample households (47.8 per cent) connected LPG stated that they partially switched over to LPG connections because it is easy to cook.

Mode of obtaining fuel wood is through gathering alone, purchasing and gathering and purchasing alone that are in the percentages of 43.5, 35.8 and 20.7

respectively. Four out of five (83 per cent) of the urban households purchase fuel wood from market whereas 61 and 69.5 percentages of the households in forest-depending and non-forest depending areas gather fuel wood from forest or common areas or from their own land. More than one-fifth (20.7 per cent) purchase as well as gather firewood; their share in forest-depending, non-forest depending and urban areas are in the percentages of 25, 20 and 17 respectively. More than half (52.7 per cent) of the total households walk an average distance of less than 1 km daily to obtain fuel wood. Nearly one-fifth (22.7 per cent) of the households have members travelling a distance between 1½ and 2 kms per day for the collection of fuel wood. The average distance travelled by households for gathering fuel wood per day is calculated as 1.52 kms. The average distance travelled for procuring fuel wood by households in urban, forest-depending and non-forest depending areas are 1.16, 1.90 and 1.50 kms respectively.

The average time taken to procure fuel wood by the urban, forest-depending and non-forest depending households are 50.09, 83.30 and 51.42 minutes respectively. Nearly half of the households transport fuel wood by head loads. Bicycle accounts for 42.7 per cent of the transportation of the fuel wood by sample households. Other modes of carrying fuel wood are not significant, accounting for the remaining 8.3 per cent. More than half (52.5 per cent) of the total sample households opined that they use firewood when the supplementary fuels like kerosene and LPG are scarce or absent. While 47.5 per cent of the remaining households stated that fuel wood is their main fuel for cooking even when the supplementary fuels are available. It is interesting to note that more than four-fifths (85.5 per cent) of the sample households responded that fuel wood is convenient to use when compared to other fuels. Other reasons for choosing fuel wood for cooking

include a wide variety such as LPG is dangerous to operate, dishes are tasty when cooking by biomass; kerosene may produce foul odour etc. Urban households expressed maximum percentages of convenient reason (90 per cent). This is followed by households depending forest (86.5 per cent) and households not depending forest (80 per cent).

More than one-third (36.8 per cent) of those affirmative of the understanding of the environmental problems due to biomass combustion gave health hazard as the most important problem. Nearly two-thirds (63 per cent) of the respondents are willing to use other fuels for cooking if they are available to them.

(vi) Exposure of IAP and Health

Duration of cooking in a household is an important factor determining the exposure to IAP. It is reported that 41.5 per cent of the sample households take less than 2 hours in everyday for cooking. Most of such households have women labourers, who prepare food only once in a day. Households cook more than once in a day have women members stay at home for taking care of their children and for cooking. The average duration of cooking per day is equal to 2.94 hours while it is 2.28, 3.44 and 3.10 hours for urban, forest-depending and non-forest depending households respectively.

Four out of every five sample households (80 per cent) have only one member engage in cooking activities everyday. Across the different types of areas, there is no significant difference in the number of women engaged in cooking in households. It is reported that 10.3 per cent (62/600) of the households have children to support women in cooking. No household has the support of more than two children in cooking. There are more households with women members staying at home for 12 hours or more in a day when compared to the households with male members of this category. It is found that

70.5 per cent have atleast one female member staying in the house for 12 hours or more per day. Only 57 of the 600 sample households or 9.5 per cent have children staying at home for 12 hours or more per day.

9. Cost of Illness

(a) Symptoms of Diseases

The respiratory diseases include nasal congestion, cough, wheezing, acute lower respiratory infection and asthma. The symptoms of the diseases of high carbon monoxide levels in the indoor air are vomiting, cognitive impairment and personality change. Other symptoms of diseases found among the sick persons comprise eye irritation, headache and dizziness.

Other symptoms of diseases of indoor pollution are widely prevalent among the households in all the three types of localities. It is followed by respiratory diseases and the least number of households reported the symptoms of high CO levels. Among the respiratory diseases cough is the most prominent symptom. It is the highest (70 out of 200 or 35 per cent) in urban households, followed by non-forest depending and forest depending households in the percentages of 29 and 13.5 respectively. High rate of wheezing cases in households located near forest may be due to the effect of IAP mixing with relatively cold air. Eye irritation is more common among other symptoms when compared to headache and dizziness.

(b) Doctors Visit

With regard to doctors visits among households with sick members it is found that 92.3 per cent made at least one visit in a month. Households depending on forest for fire wood made the least number of visits to the doctors as compared to urban and non-forest depending households with sick persons. The sample households consulted doctor for

diseases due to indoor air pollution and paid consultation fees in the last month of the survey accounted for 90.7 per cent.

(c) Medicines

Out of the total households having sick persons due to IAP, 58.3 per cent spent between Rs.20 and Rs.60 per month for medicines. The highest monthly expenditure class of Rs.100 and above on medicines has more number of urban households. It is estimated that the average annual expenditure on medicines comprising of urban, forest-depending and non-forest depending households are Rs.282.33, Rs.266.88 and Rs.295.43 respectively.

Across different localities, it is found that more than three-fifth (62.9 per cent) of the urban households incur a transportation cost of less than Rs.40 per month while it is 22.4 and 27.6 percentages respectively of the households in forest depending and non-forest depending areas. The average annual expenditure on transportation cost of the urban, forest-depending and non-forest depending households are Rs.39.98, Rs.67.44 and Rs.57.12 respectively. More than one-third (37.8 per cent) of the households having sick persons incurred a transportation cost between Rs.100 and Rs.200 in a year. Majority of the households are found in the transportation expenditure class of Rs.100 to Rs.200 in the percentages of 41.2, 34.5 and 33.3 respectively of forest-depending, urban and non-forest depending households.

(d) Hospitalisation

The percentage of households having hospitalised members for urban, forest-depending and non-forest depending areas are 29, 34 and 4.5 respectively. More than three-fifth (68.1 per cent) of the total households have at least one sick member

hospitalised once in a year. The average frequency of hospitalisation in a year is estimated as 2.67 days. Across the different localities, households depending on forest have higher frequency of hospitalisation. Average frequency of hospitalisation in a year by the urban households is 3.66 days with a standard deviation of 2.22 when compared to 4.84 and 3.89 days with a standard deviation of 2.65 and 2.42 respectively for forest-depending and non-forest depending households.

(e) Room Rent

More than half (50.4 per cent) of the households having hospitalised members are assisted by only one care taker. No household in urban and non-forest depending areas have more than three care takers. More than half of the total households with hospitalised members paid a room rent of rupees below 400 per year. One fifth of the households incurred a room rent of Rs.2000 and above per year. It is estimated that the average annual expenditure on room rent of the urban, forest depending and non-forest depending households are Rs.861.90, Rs.1607.72 and Rs.694.44 respectively.

(f) Medical Test

More than one fourth of the households having hospitalised members incur an expenditure of less than Rs.200 per annum for medical test. No household from non-forest depending areas spent more than Rs.1000 or more for medical test. But households in the forest depending areas paid more for medical test.

(g) Wage Loss

Out of the 135 households with hospitalised members, 48.1 per cent lost job for 2 to 3 days in a year. The highest employment loss recorded is 8 and 9 days in a year comprising 8.9 and 5.9 percentages respectively of the households. No household in

urban and non-forest depending area has an employment loss of 9 or more than 9 days. It is estimated that the employment loss to the sick persons of the urban, forest depending and non-forest depending households are 3.48, 4.81 and 3.89 days respectively. More than one-third (37.8 per cent) of the households lost wages less than Rs.300 per year. Loss of wages to the households having sick persons in the lowest wage loss class is the maximum in urban areas and minimum in forest-depending households. The average annual wage loss to the sick person of the urban, forest depending and non-forest depending households are estimated as Rs.459.14, Rs.758.74 and Rs.713.89 respectively.

The number of days of wage loss to the households having caretakers below 3 days and 3 to 6 days in a year account for 31.1 and 30.4 percentages respectively. The number of days of wage loss is very high (29.4 per cent) in the case of households depending forest for fuel woods. The average annual employment loss to the households having caretakers representing urban, forest depending and non-forest depending households are estimated as 5.59, 9.22 and 7.00 days respectively. Nearly half (47.4 per cent) of the households having caretakers lost wage to the tune of less than Rs.500 per year. The average annual wage loss to the households having caretakers of the urban, forest depending and non-forest depending areas are estimated as Rs.629.57, Rs.1279.12 and Rs.453.33 respectively.

Less than half of the households having hospitalised members incurred a wage loss of less than Rs.1000 per year. Most of the high wage loss households are found in the forest depending households. The average annual wage loss of sick persons and the caretakers of the urban, forest depending and non-forest depending households are estimated as Rs.1078.36, Rs.2039.49 and Rs.1175.00 respectively.

10. Total Annual Direct Cost of Sickness

Total annual direct cost of sickness is estimated by summating the cost of consultation, medicines purchased, transportation cost of sick persons and care takers, lodging medical test and wage loss of sick persons and caretakers.

The study revealed that 90.7 per cent of the sample households have atleast one sick member affected by IAP. Out of these health affected households, 24.8 per cent admitted their sick members in hospitals for treatment. Households with outpatients incur less expenditure, while the average annual cost of hospitalisation of households with inpatients is relatively high (Table 6).

It is found that more than two-fifth (42 per cent) of the households are concentrated in the expenditure class of Rs.500 – Rs.1000. The number of households decreases with the increase of total annual direct cost of sickness. However 11.4 per cent of the households with sick persons are found in the highest expenditure class of Rs.3500 and above. In all the three localities, maximum numbers of households are concentrated in the expenditure class of Rs.500 – Rs.1000 but nearly three-fifth of the non-forest depending households represented in the expenditure class when compared to 37.6 and 32.6 percentages respectively of the households in urban and forest-depending areas. The largest representation in the highest expenditure class of Rs.3500 and above is by forest-depending households accounting 21.2 per cent in comparison with 8.4 and 3.4 percentages respectively of the urban and non-forest depending households. It is estimated that the average annual total direct cost of sickness of the urban, forest depending and non-forest depending households are Rs.1649.62, Rs.2406.19 and Rs.1166.10 respectively (Table 7).

11. Model

In order to assess the multi-dimensionality of cost of illness due to IAP, it is regressed on various independent variables. Number of sick persons, number of cooking hours per day, average annual household income, total quantity of fuel wood consumption per annum, area of the kitchen, number of caretakers for the sick persons, kitchen ventilation, provision of chimney, presence of fuel-mix for cooking and the number of days of hospitalisation per year. Hence the predictor variable is the cost of illness (COI) and the 10 criterion variables are stated above. In order to assess the interdependence or multi-collinearity, the criterion variable and the predictor variables are subjected to Pearson Product Moment Correlation analysis. The computation of the correlation index along with the predictor variables resulted in inter-correlation matrix (Table 8).

The correlation matrix revealed that some of the criterion variable show high degree of positive correlation (number of days of hospitalisation per year and number of caretakers for the sick persons) between the predicator variables and the criterion variable. Some of the closely related variables depicting IAP are also included in the model. There is a high degree of positive correlation exist between number of days of hospitalisation per year and the cost of illness (+0.686). It means that households hospitalised their members for more number of days in a year have high cost of illness. The second set of variables showing high degree of positive correlation of 0.625 is number of caretakers for the sick persons and cost of illness. This attribute shows that those households having more caretakers for the sick persons have high cost of illness. It is worth noting that inter -correlation of predictor variables show very less degree of

positive and negative correlation. Thus the model avoids the problem of multi-collinearity among the predictor variables.

In order to find the degree of association between COI as the criterion variable and the 10 predictor variables, the model assumes a linear relationship between the criterion and predictor variables. The linear function of the predictor variables and the criterion variable can be expressed in the following form.

$COI = f (X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10})$

Where

COI	=	Cost of illness per household per annum.
X_1	=	Number of sick persons per household in the last year
X_2	=	Number of cooking hours per day
X_3	=	Average annual household income
X_4	=	Average quantity of fuel used per year
X_5	=	Area of the kitchen
X_6	=	Number of caretakers to the sick person
X_7	=	Kitchen ventilation
X_8	=	Provision of chimney
X_9	=	Availability of fuel mix
X_{10}	=	Number of days of hospitalisation per household.

The descriptive statistics of the criterion and the predictor variables is shown in Table 9.

The regressing of the linear function is done through the enter method. The econometric specification of the final regression model is shown as:

$$COI = \beta_o + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + \beta_9X_9 + \beta_{10}X_{10} + \mu$$

Where β_o is constant and β_1 to β_{10} are the regression coefficients. The criterion and predictor variables are entered into linear regression analysis. The model summary and ANOVA are presented in Table 10 and Table 11.

The summary results indicate that r = 0.72 which is the correlation between criterion variable and predictor variables. The R^2 value of 0.518 indicates the proportion of the variability in the dependent variable which is accounted for by the multiple regression equation.

The analysis of variance (ANOVA) shows the sum of squares explained by the regression equation is more than which is left unexplained. The F statistic of 57.364 is significant at zero per cent level, which is well below the probability value of 0.05. From this, it is very clear that one can assume a linear relationship between the predictor variables and the dependent variable.

The coefficient values are furnished in Table 12. The intercept of the regression equation (constant) is found as -197.615. The t-values of the predictor variables show that they are significantly different from zero. The beta values are very high in the case of number of days of hospitalisation and number of caretakers.

12. Conclusion

Indoor air pollution causes respiratory and other health problems to more than 90 per cent of the biomass users. Cost of illness is less in the case of households with more severe health problems if their affordability and accessibility to medical care is less. The socio-economic and housing characteristics play a dominant role in fuel selection, consumption and the overall household health burden. Better placed fuel using households manage the health problems better when compared to the relatively poor households. Hospitalisation of the sick persons cost the households heavy where number of days of hospitalisation and number of caretakers to the sick persons are more. The intangible costs of the sick persons mainly women and children are difficult to measure.

Urban households are better placed when compared to the rural households both in terms of the availability of quality of fuels and accessibility to various medical facilities. Hence provision of modern cooking fuel should be one of the poverty alleviating components and health ensuring provisions of public policies.

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Table 1. Estimates of different types of bio-fuel consumption in rural households (million tonnes per annum)

Surveying Agency	Years of Survey	Fuel Wood	Dung Cake	Crop Residues
NCAER	1978-79	93.3	83.2	36.7
REDB	1985-92	181-309	40-115	32-166
IREP	1990-91	169.0	54.2	62.8

Source: TERI, 1995, Vol.56.

Table 2. Change in fuel mix for cooking in rural and urban

Fuel Type	Percentage of Rural Household			Percentage of Urban Household		
	1983-84	1993-94	1999-2000	1983-84	1993-94	1999-2000
Bio-fuels	97.20	93.80	88.40	69.10	41.40	28.20
Kerosene	0.82	2.00	2.70	16.71	23.60	21.70
LPG	0.24	1.90	5.40	10.29	29.60	44.20
Electricity	1.74	2.30	3.50	3.90	5.40	6.90
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source: Sudhakara Reddy, IGIDR, Mumbai.

Table 3. Household energy consumption

Energy Carrier	1980	Percentage of Total	1990	Percentage of Total	2000	Percentage of Total
Biomass	4436.80	93.21	4853.57	89.04	5527.8	81.46
Kerosene	234.67	4.93	380.48	6.98	559.2	8.24
LPG	53.79	1.13	111.75	2.05	286.4	4.22
Electricity	35.22	0.74	105.20	1.93	411.91	6.07
Total	4760	100.0	5451	100.0	6786	100.0

Source: Sudhakara Reddy, IGIDR, Mumbai.

Table 4. Descriptive statistics of demographic variables

Demographic variables	Urban Households			Rural Households			Total		
	N	Mean	Std. Deviation	N	Mean	Std. Deviation	N	Mean	Std. Deviation
Size of the family	200	4.3100	1.06752	400	4.4150	1.21303	600	4.3800	1.16671
Number of male children	117	1.3846	0.61372	290	1.4448	0.62701	407	1.4275	0.62306
Number of female children	157	1.4459	0.72849	260	1.3577	0.63894	417	1.3909	0.67455
Male children attending school at the school going age (5 to 15)	51	1.1765	0.38501	120	1.2833	0.62421	171	1.2515	0.56458
Female children attending school at the school going age (5 to 15)	58	1.2414	0.53999	91	1.2308	0.51805	149	1.2349	0.52491
Number of children below 5 years	24	1.2083	0.50898	43	1.3023	0.46470	67	1.2687	0.47933
Number of working aged male members (15 to 59 years)	198	1.1212	0.34236	400	1.1950	0.45551	598	1.1706	0.42257
Number of working aged female population (15 to 59 years)	199	1.0553	0.25017	400	1.0475	0.21297	599	1.0501	0.22583
Number of male members unemployed in the working age	46	1.2174	0.46729	144	1.3056	0.49158	190	1.2842	0.48606
Number of female members unemployed in the working age	110	1.4364	0.73606	254	1.5394	0.74681	364	1.5082	0.74408
Number of male aged members (60 years and	23	1.0000	0.00000	56	1.0000	0.00000	79	1.0000	0.00000

above)									
Number of female aged members (60 years and above)	18	1.0000	0.00000	41	1.0000	0.00000	59	1.0000	0.00000
Number of married members in the marriageable age	95	1.5158	0.93243	204	1.8775	0.92031	299	1.7625	0.93791
Number of child labourers	3	1.3333	0.57735	4	1.0000	0.00000	7	1.1429	0.37796
Number of aged labourers	19	1.1579	0.37463	46	1.4565	0.88711	65	1.3692	0.78201

Source: Field Survey

Table 5. Descriptive statistics of monthly expenditure

Expenditure Items	Urban Households			Rural Households			Total		
	N	Mean	Std. Deviation	N	Mean	Std. Deviation	N	Mean	Std. Deviation
Expenditure on food	200	2400.0000	1012.77022	400	2861.8125	1445.24743	600	2707.8750	1334.00274
Fuel	199	390.3894	165.40509	357	294.9496	221.20475	556	329.1088	207.95250
Education	159	532.3899	369.91867	291	988.0584	1510.50246	450	827.0556	1252.73751
Rent	97	1097.5258	821.97809	70	530.1429	373.53576	167	859.7006	726.34870
Clothing	170	507.6471	696.90804	356	587.5646	1443.20119	526	561.7357	1251.45207
Medicine and consultation fee	160	356.5625	387.18147	385	354.0260	351.18349	545	354.7706	361.76395
Ritual and ceremonies	129	368.2171	530.47510	270	435.2630	932.77360	399	413.5865	824.34685
Habits	77	253.5714	268.57673	235	389.3830	668.41769	312	355.8654	597.68825
Transport	112	499.1071	554.50579	331	436.0423	408.94734	443	451.9865	450.36750
Interest payments	104	1032.3077	1039.81629	288	1374.6875	1559.49259	392	1283.8520	1446.67467
Others	13	1073.0769	811.02183	142	1135.6690	2043.38148	155	1130.4194	1968.37372
Total household expenditure	200	5681.9125	2914.29782	400	7076.6525	4897.39400	600	6611.7392	4385.30504

Source: Field Survey

Table 6. Total annual direct cost of sickness

Components of Direct Cost of Sickness	Number of Households	Average Annual Expenditure (Rs)	Standard Deviation
Cost of consultation	544	81.28	41.55
Medicines purchased	544	76.65	63.31
Transportation cost of sick persons	544	55.15	35.68
Transportation cost of care takers	135	344.60	429.48
Lodging	135	1226.41	1616.00
Medical test	135	726.85	818.23
Wage loss	135	627.03	475.74
Total	544	1763.17	2444.90

Table 7. Distribution of total annual direct cost of sickness

Total Annual Direct Cost of Sickness (in Rs)	Urban Households	Rural Households			Grand Total
		Forest Depending	Non-Forest Depending	Total	
Below 500	32 (18.0)	13 (6.8)	17 (9.8)	30 (8.2)	62 (11.4)
500-1000	67 (37.6)	62 (32.3)	99 (56.9)	162 (44.1)	228 (41.9)
1000-1500	28 (15.7)	29 (15.1)	33 (19.0)	62 (16.9)	90 (16.5)
1500-2000	15 (8.4)	18 (9.4)	6 (3.4)	24 (6.5)	39 (7.2)
2000-2500	9 (5.1)	11 (5.7)	6 (3.4)	17 (4.6)	26 (4.8)
2500-3000	9 (5.1)	6 (3.1)	6 (3.4)	12 (3.3)	21 (3.9)
3000-3500	3 (1.7)	12 (6.2)	1 (.6)	13 (3.5)	16 (2.9)
3500 and above	15 (8.4)	41 (21.4)	6 (3.4)	47 (12.8)	62 (11.4)
Total	178 (100.0)	192 (100.0)	174 (100.0)	367 (100.0)	544 (100.0)

Source: Field Survey
Note: Figures in the brackets indicate column percentage.

Table 8. Inter-correlation Matrix

Pearson Correlation	Cost of illness	Number of sick persons	Cooking hours per day	Annual household income	Quantity of fuel used	Area of the kitchen	Number of caretakers to the sick person	Kitchen ventilation	Provision of chimney	Availability of fuel mix	Number of days of hospitalisation per household
Cost of illness	1.000										
Number of sick persons	.031	1.000									
Cooking hours per day	-.046	.059	1.000								
Annual household income	.185	.156	.032	1.000							
Quantity of fuel used	.072	.150	.269	.187	1.000						
Area of the kitchen	.215	.167	-.116	.314	.088	1.000					
Number of caretakers to the sick person	.625	-.090	-.070	.112	-.029	.136	1.000				
Kitchen ventilation	.097	-.135	-.101	-.011	-.134	.019	.078	1.000			
Provision of chimney	-.035	.022	-.264	.001	-.079	-.003	-.048	.241	1.000		
Availability of fuel mix	-.095	.167	.129	.136	.178	-.038	-.062	-.058	-.032	1.000	
Number of days of hospitalisation per household	.686	-.048	-.104	.119	-.002	.211	.780	.046	-.057	-.114	1.000

Table 9. Descriptive statistics

	Mean	Std. Deviation	N
Cost of illness	4192.0313	5715.91327	544
Number of sick persons	1.5607	0.78428	544
Cooking hours per day	2.9471	1.42080	544
Annual household income	10237.1930	7956.68073	544
Quantity of fuel used	1709.7794	1331.32498	544
Area of the kitchen	83.1838	49.74009	544
Number of caretakers to the sick person	0.4026	0.80381	544
Kitchen ventilation	0.3419	0.47479	544
Provision of chimney	0.7537	0.43127	544
Availability of fuel mix	0.1232	0.32893	544
Number of days of hospitalisation per household	1.0478	2.21694	544

Table 10. Summary table

Model	R	R Square	Adjusted R Square	Change Statistics			Durbin-Watson
				R Square Change	F Change	Sig. F Change	
1	0.720(a)	0.518	0.509	0.518	57.364	0.000	1.888

Table 11. ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9196116437.539	10	919611643.754	57.364	.000(a)
	Residual	8544597360.930	534	16031139.514		
	Total	17740713798.469	544			

Table 12. Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-197.615	733.680		-.269	0.788
	Number of sick persons	484.415	231.200	0.066	2.095	0.037
	Cooking hours per day	48.429	132.348	0.012	0.366	0.715
	Annual household income	0.053	0.023	0.074	2.257	0.024
	Quantity of fuel used	0.296	0.139	0.069	2.124	0.034
	Area of the kitchen	4.470	3.792	0.039	1.179	0.239
	Number of caretakers to the sick person	1686.053	344.787	0.237	4.890	0.000
	Kitchen ventilation	910.617	380.305	0.076	2.394	0.017
	Provision of chimney	-127.435	427.346	-0.010	-0.298	0.766
	Availability of fuel mix	-947.505	546.816	-0.055	-1.733	0.084
	Number of days of hospitalisation per household	1234.945	126.791	0.479	9.740	0.000