DETERMINANTS OF INDOOR FUEL CHOICE IN INDIA: AN ANALYSIS

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Abstract: Indoor Air pollution is considered as one of the major contributors to human death and illness. The indoor pollution is more dangerous for those who spend more time indoor, especially in front of the source of the pollution. Women and children bear the maximum risk. Developing countries are the main victims of diseases induced by indoor pollution. The extent of indoor air pollution, to a large extent, depends upon the pollution generated by the type of fuel used in cooking and heating purpose. This paper attempts to analyse the choice of fuels by the Indian population, by both rural and urban areas using NSSO 60th round database. Monthly per capita income and education of the household head found to be important determinants, among others, of fuel choice by the household. Awareness program in terms of basic education and campaigns may provide potential solution to the problem.

Keywords: Indoor Environment, Fuel Choice, Indian Households, Education

Introduction

WHO factsheet (2005) says indoor air pollution (IAP) causes 1.6 million death every year. Diseases that are caused by IAP mainly are respiratory illness, asthma, lung cancer, pneumonia etc. WHO (2009) reports that 3.9% of deaths occur in low and middle income countries from indoor smoke from solid fuels. The overall disease burden includes acute lower respiratory illness, chronic obstructive pulmonary, cancers in the trachea, lung and bronchus and many others. In the developing world IAP is considered to be the 4th most important risk factor of mortality.

The indoor pollution is more dangerous for those who spend more time indoor, especially in front of the source of the pollution. The cultural practices of the developing countries make women, children, elderly and sick people more vulnerable to such pollution. It gets more worse in the winter season when it takes more time for cooking and heating.

The extent of indoor air pollution, to a large extent, depends upon the type of fuel used in cooking and heating purpose. Fuels that generate more pollution coupled with poor ventilation of the place of cooking make the situation worse. The type of fuel that is used in the household largely depends on the fuel choice by the household. The choice of fuel, in turn depends on the affordability of the

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household, awareness of the primary decision maker in the household and availability of the chosen fuel in the locality. In general, especially in the developing countries, women have less or limited participation in the decision making process of the fuel choice. Men enjoy greater control in choosing the fuel even in the households who can afford cleaner and efficient fuels and appliances. So, the final choice depends on how aware the main decision maker is about the harmful effect of the polluting fuels.

Solid biomass fuels that include wood, charcoal, dung and crop residues are used by around 2.5 billion people worldwide as their main source of cooking, heating and lighting (Reddy et al., 1996; Smith et al., 2004). The use of biomass fuels are gradually increasing among the poor households (Albalak R, 1997). In fact, availability of the less polluting fuel does not always ensure the use of the same. Smith (1987) discussed that in developing countries people continue to use biomass fuels even when less polluting fuels are available.

The fuel use pattern differs greatly between the rural and urban areas. In South Asia and sub-Saharan Africa, there are areas in the rural fringes where almost 100% of the people depend on the solid biomass fuels (Rehfuess EA, Bruce NG and Smith KR, 2011). However, in the urban areas there has been a switching from solid biomass fuels to LPG as shown by a study by Alam, Sathaye and Barnes (1998). It was also revealed in a studies that LPG is widely used in the urban fringes of India [Heidi, Mest & Eske Land (2009)]

Many studies are have showed higher affluence of the households cause shift from traditional biomass fuels to advanced less polluting fuels in Indian households (Saatkamp, Masera & Kammen, 2000, Kavi Kumar and Viswanathan, 2005). However, affluence does not always explain the fuel choice by the households. There are factors like availability and fuel prises awareness, the traditional and cultural practices and household tastes and preferences also explain the fuel choice (Mekonnen and Köhlin, 2009). This paper tries to find the main driving factors that determine the fuel choice in the Indian households, both rural and urban and based on the results it attempts to suggest policies that may potentially reduce the menace of IAP exposure and subsequent health impacts.

Data and Methodology

The study uses 60th round of National Sample Survey Organisation (NSSO) database. The information were collected during 1st January 2004 and 30th June 2004. Schedule 25 on 'Morbidity and Health Care' has been used here. The schedule provides information on household characteristics including fuel choice by the households and also the general demographic profile of the individuals. Total number of households surveyed was 73,868. Among them 64.04% are from rural area and 35.96% are from urban area.

The information which are relevant for the study are energy use or fuel use by

the household, monthly per capita expenditure of the household, household type, house structure, education and sex of the head of the household. The determinants of the fuel choice by the households are attempted to be found using a LOGIT regression model. The dependent variable is the fuel use pattern. This has been made binary and that explains the use of LOGIT model. The independent variables used here are monthly per capita expenditure (MPCE) of the household, household type, house structure, education and sex of the head of the household. The variables are described below in detail.

Dependent Variable

fueltype: NSSO provides information on ten types of fuels used by the household. They are coke/coal, firewood and chips, LPG, gobar gas, dung cake, charcoal, kerosene, electricity, others and no cooking arrangements. The study divided it in two groups, namely 'dirty' fuel and 'clean' fuel (Dutta, 2013, 2014) and excludes the households with no cooking arrangement. Clean fuels include LPG, kerosene and electricity. The rest are clubbed and named as 'dirty' fuel. A binary variable is created with value 1 assigned for the clean fuel and 0 for the dirty fuel.

$$\left.\begin{array}{ll} fueltype = 1 & \text{if clean fuel} \\ \quad\quad\;\; = 0 & \text{if dirty fuel} \end{array}\right\}$$

Independent Variables

Monthly per capita expenditure (mpceclass) : This is grouped in to four quintiles. They are *poorest, poorer, middle* and *rich.*

House Structure: The database provides five types of structure of house. They are *pucca (code 1), semi-pucca (code 2), serviceable kutcha (code 3), unserviceable kutcha (code 4)* and *no structure (code 5)*. Codes are used for each type. An index of house structure has been created to normalise the score in the following manner:

House structure index =

$$\frac{\text{Actual code} - \text{Minimum code}}{\text{Maximum code} - \text{Minimum code}}$$

This is denoted as *hsindex.*

Household type: There are five and four different household types for rural and urban areas respectively. For rural areas, they are *self-employed in non-agriculture (code 1), agricultural labour (code 2), other labour (code 3), self- employed in agriculture (code 4)*, and *others (code 5)*. For urban areas they are *self-employed (code 1), regular wage/salary earning (code 2), casual labour (code 3)*, and *others (code 4)*. Different codes are used for each type. In the similar manner like house structure an index of house type is created for rural and urban areas separately.

House type index =

$$\frac{\text{Actual code} - \text{Minimum code}}{\text{Maximum code} - \text{Minimum code}}$$

This is denoted as *htindex.*

Education of the Head of the Household: There are ten categories of education level listed in the dataset. They have been recoded and clubbed into four categories, namely, *not literate (code 1), educated up to primary level (code 2), educated up to secondary level (code 3) and higher secondary*

and above (code 4). Education index has been constructed and denoted as *eduindex*.

Education index =

$$\frac{\text{Actual code} - \text{Minimum code}}{\text{Maximum code} - \text{Minimum code}}$$

Sex of the household head: This is binary variable and used in the original form as in the dataset. 1 is assigned for male and 2 is assigned for female headed households. It is denoted as *sexhh.*

Age of the household head: it is taken in the original form as given in the dataset. It is denoted as *agehh.*

Descriptive analysis is conducted to examine two-way relationship between the fuel use pattern and other variables. Pairwise correlation is also run to check the presence of significant relationship among the variables described above. Binary LOGIT regression is conducted to find out the causal relation between the dependent and independent variables. The exercise is carried out to find out significant determinants of the fuel choice by the Indian population. This is done separately for rural and urban households.

Results and Discussion

Descriptive Analysis

Table 1 presents the choice of fuel type among rural and urban households. 90.15% of the rural households use dirty fuels where the figure for urban counterpart is only 29.24%. Overall more than 68% of Indian households use dirty fuels. The use of clean fuels among the urban households is approximately 71%. On the other side, 84.73% of the households who use dirty fuels reside in rural area. The use of clean fuel users mostly are from urban fringes. The dirty fuel is more of a problem for the rural households, though more than 29% urban households use the same.

Table 1: Fuel Choice (%) Across Sectors

Sector	Fuel type Dirty	Clean	Total
Rural			
Row %	90.15	9.85	100
Column %	84.73	20.03	64.28
Urban			
Row %	29.24	70.76	100
Column %	15.27	79.97	35.72
Total			
Row %	68.39	31.61	100
Column %	100	100	100

Source: Author's calculation

As the dirty fuel use is very large among the rural households, it is further shown the particular type of dirty fuel that are used in the rural areas. Similarly in the urban areas, clean fuel is more common, so the type of clean fuel is further shown.

Table 2: Use of Dirty Fuels (%) in Rural India

Fuel type (rural using dirty fuel only))	Percent
Coke/Coal	0.88
Firewood & Chips	86.01
Gobor gas	0.29
Dung Cake	9.5
Charcoal	0.07
No Cooking arrangement	0.25
Others	3.01
Total	100

Source: Author's calculation

Table 3: Use of clean fuels (%) in urban India

Fuel type (urban using clean fuel only)	Percent
LPG	88.17
Kerosene	11.35
Electricity	0.48
Total	100

Source: Author's calculation

Table 2 shows that most commonly used fuel in rural India is firewood and chips followed by dung cake. Both are solid biomass fuels having significant impact on the health for the people who are mostly exposed to them. Table 3 reveals that LPG is the most common fuel choice among the clean fuel users in urban India. This is followed by kerosene. They together comprise of 99.52% of the total clean fuel use in the urban area.

The fuel choice is different across households. Choice of fuel largely depends upon the economic condition of the households. So, it is examined how it varies across different income classes. Monthly per capita expenditure (MPCE) is taken as the proxy for economic status

of the households. The variation of fuel choice across MPCE class for rural and urban households are shown in table 4 and 5 respectively. It is evident from table 4 that in rural areas, dirty fuel is largely used by the households in the lower economic stratum and the percentage of use gradually goes down as the income rises. 98.39% of the poorest class uses dirty fuel and the figure becomes 73.56 among the rich households. The clean fuels are used only by 1.61% of the poorest households in the rural area where as large as 26.44% of the rich households use the clean fuel in rural India. In urban area the dirty fuel use falls drastically across MPCE classes. 62.51% of the poorest households use dirty fuels and it becomes only 5.50% of the rich households in urban area. 37.49% of the poorest and 94.50 % of the rich households use clean fuels in urban India respectively. Percentage of those who use dirty fuels gradually goes down as the households progress in the income class both in urban and rural areas.

Table 4: Use of Fuels (%) Across MPCE Class in Rural India

MPCE Class (Rural)	Fuel Type		
	Dirty	**Clean**	**Total**
Poorest			
Row %	98.39	1.61	100
Column %	27.3	4.09	
Poorer			
Row %	96.45	3.55	100
Column %	26.76	9.01	
Middle			
Row %	92.1	7.9	100
Column %	25.62	20.14	
Rich			
Row %	73.56	26.44	100
Column %	20.29	66.76	
Total			
Row %	90.15	9.85	100
Column %	100	100	100

Source: Author's calculation

Table 5: Use of Fuels (%) aAcross MPCE Class in Urban India

MPCE Class (Urban)	Fuel Type		
	Dirty	**Clean**	**Total**
Poorest			
Row %	62.51	37.49	100
Column %	54.21	13.44	25.17
Poorer			
Row %	32.69	67.31	100
Column %	29.25	24.89	25.99
Middle			
Row %	14.62	85.38	100
Column %	11.90	28.71	23.84
Rich			
Row %	5.50	94.50	100
Column %	4.64	32.96	24.99
Total			
Row %	29.25	70.75	100
Column %	100	100	100

Source: Author's calculation

Awareness plays an important role in the decision regarding fuel choice. So education of the household head who is supposed to be the primary decision maker is considered and two-way descriptive analysis carried out to examine the how awareness is related to fuel choice. This is shown in table 6 and 7 for rural and urban areas respectively.

Table 6: Use of Fuels (%) Across Educational Attainment in Rural India

	Fuel type		
Education (rural household head)	**Dirty**	**Clean**	**Total**
Not literate			
Row %	96.57	3.42	100
Column %	47.84	15.54	
Upto Primary			

Row %	91.81	8.19	100
Column %	28.70	23.42	
Upto Secondary			
Row %	82.22	17.78	100
Column %	19.21	38.01	
Higher Secondary and above			
Row %	62.78	37.22	100
Column %	4.25	23.03	
Total			
Row %	90.15	9.85	100
Column %	100	100	

Source: Author's calculation

Table 6 reveals that awareness expressed through educational attainment matters in the use of fuel in rural India. The use of dirty fuels is most common among the households whose heads are not literate. The use gradually decreases as the education level goes up. Those who are using dirty fuels, the not literate heads are most in percentage, and heads with education level higher secondary and above are the lowest. This is also true for the urban households. This is shown in table 7.

Table 7: Use of Fuels (%) Across Educational Attainment in Urban India

	Fuel type		
Education (Urban household head)	**Dirty**	**Clean**	**Total**
Not literate			
Row %	59.15	40.85	100
Column %	39.52	11.28	19.4
Upto Primary			
Row %	39.88	60.12	100
Column %	30.88	19.24	22.72
Upto Secondary			
Row %	20.74	79.26	100

Column %	22.93	36.19	32.22
Higher Secondary and above			
Row %	7.64	92.36	100
Column %	6.67	33.30	25.66
Total			
Row %	29.24	70.76	100
Column %	100	100	100

Source: Author's calculation

The household type is also considered to be important to understand the relation between the nature of the households and the fuel choice. This is separately shown for rural and urban areas in tables 8 and 9 respectively. In rural India, households which work as agriculture labour use the dirty fuel the most followed by those who are self-employed in agriculture and other labour. Clean fuels are mostly used by those households who are neither engaged in agriculture nor they are self-employed in non-agriculture. It is those who are of 'other' type use the clean fuels most followed by self-employed in non-agriculture. Among the dirty and clean fuel users percentage of self-employed in agriculture and the others are the highest respectively. For the urban households also the use of dirty fuel is highest among the households work as casual labours followed by those who are self-employed. Among those who use dirty fuels the highest percentage is belonged by the self-employed households. 83.84% households who have regular wage or salary earnings use clean fuels followed by others and self-employed.

Table 8: Use of Fuels (%) Across Household Type in Rural India

	Fuel type		
Household type (Rural households)	**Dirty**	**Clean**	**Total**
Self Employed in non-agriculture			
Row %	83.97	16.03	100
Column %	13.98	24.43	
Agricultural labour			
Row %	98.18	1.82	100
Column %	24.08	4.09	

Other labour			
Row %	90.45	9.55	100
Column %	10.3	9.95	
Self-employed in agriculture			
Row %	93.43	6.57	100
Column %	41.82	26.91	
Others			
Row %	72.24	27.76	100
Column %	9.83	34.6	
Total			
Row %	90.15	9.85	100
Column %	100	100	

Source: Author's calculation

Table 9: Use of Fuels (%) Across Household Type in Urban India

	Fuel type		
Household type (Urban households)	**Dirty**	**Clean**	**Total**
Self-Employed			
Row %	31.06	68.94	100
Column %	43.01	39.44	
Regular Wage/Salary earnings			
Row %	16.16	83.84	100
Column %	21.23	45.52	
Casual labour			
Row %	68.62	31.38	100
Column %	27.21	5.14	
Others			
Row %	26.27	73.73	100
Column %	8.54	9.90	

Total			
Row %	29.23	70.77	100
Column %	100	100	

Source: Author's calculation

Table 10 and 11 show the two-way relation between house structure and the fuel choice for rural and urban households of India respectively.

Table 10: Use of Fuels (%) Across House Structure Type in Rural India

	Fuel type		
House structure (for rural households)	**Dirty**	**Clean**	**Total**
Pucca			
Row %	82.42	17.58	100
Column %	41.94	81.88	
Semi-Pucca			
Row %	95.62	4.38	100
Column %	35.75	15	
Serviceable kaccha			
Row %	98.45	1.55	100
Column %	19.96	2.88	
Unserviceable Kaccha			
Row %	1.00	99.00	100
Column %	2.34	0.22	
No structure			
Row %	75	25	100
Column %	0.01	0.02	
Total			
Row %	90.15	9.85	100
Column %	100	100	

Source: Author's calculation

Rural households who live in kaccha houses mostly use the dirty fuels followed by those live in semi-pucca and pucca houses. Most of households who use clean fuels live

in pucca houses even in the rural areas. Among urban households also, those who have kaccha houses use dirty fuels largely followed by semi pucca houses. Most of the pucca house-owners use clean fuels. Among both of dirty and clean fuel users percentage of households living in pucca houses are the highest, though this is much higher in case of clean fuel users.

Table 11: Use of Fuels (%) Across House Structure Type in Urban India

	Fuel type		
House structure (for urban households)	**Dirty**	**Clean**	**Total**
Pucca			
Row %	21.19	78.81	100
Column %	59.13	90.87	81.77
Semi-Pucca			
Row %	60.46	39.54	100
Column %	27.98	7.56	13.4
Serviceable kaccha			
Row %	76.65	23.35	100
Column %	10.92	1.37	4.13
Unserviceable Kaccha			
Row %	82.12	17.88	100
Column %	1.92	0.17	0.67
No structure			
Row %	50.00	50.00	100
Column %	0.05	0.02	0.03
Total			
Row %	29.24	70.76	100
Column %	100	100	100

Source: Author's calculation

As the two-way descriptive analysis shows a presence of relationship between the MPCE class, education, household type and structure of the houses it is imperative to examine the pairwise correlation among them followed by a regression analysis to find out the causal direction of the relation. In the correlation

and regression both, age and sex of the household heads are also included as they are considered to be as potential determining factors when decision about the fuel choice is made.

Correlation analysis

The pairwise correlation between the variable described before are checked. Here the index variables are used and the exercise is done both for rural and urban areas. These are shown in table 12 and 13 respectively.

Table 12: Pairwise correlation among variables (Rural)

	fueltype	*eduindex*	*hsindex*	*htindex*	*mpceclass*	*sexhh*	*agehh*
fueltype	1.00						
eduindex	0.2804*	1.00					
hsindex	-0.2224*	-0.2151*	1.00				
htindex	0.0770*	0.1261*	-0.1029*	1.00			
mpceclass	0.2953*	0.2558*	-0.2393*	0.1839*	1.00		
sexhh	0.0090	-0.1802*	-0.0153*	0.0904*	0.0650*	1.00	
agehh	0.0278*	-0.2045*	-0.0739*	0.1450*	0.0913*	0.1013*	1.00

*Source: Author's calculation, *significant at 5% level*

Table 13: Pairwise correlation among variables (Urban)

	fueltype	*eduindex*	*hsindex*	*htindex*	*mpceclass*	*sexhh*	*agehh*
fueltype	1.00						
eduindex	0.4052*	1.00					
hsindex	-0.3663*	-0.2626*	1.00				
htindex	-0.0558*	-0.0434*	0.0608*	1.00			
mpceclass	0.4646*	0.4747*	-0.2974*	0.0286*	1.00		
sexhh	-0.0410*	-0.2408*	0.0313*	0.1938*	-0.0113*	1.00	
agehh	0.0425*	-0.1273*	-0.0680*	0.1109*	0.0888*	0.1538*	1.00

*Source: Author's calculation, *significant at 5% level*

Positive significant correlation is found between education index and the fuel use type both urban and rural areas. Negative significant correlation between house structure and the fuel type implies more use of dirty fuels among the kutcha

houseowners than pucca house owners. It corroborates our earlier finding from two-way descriptive analysis. Negative significant correlation also exists for the house type and fuel use for urban areas. MPCE class is positively related to fuel use type both in urban and rural areas. Age of the household head also plays a positive significant role in determining fuel type.

Regression Analysis

The causal direction of the relation between the fuel type and the independent variables is found when the regression analysis is carried out. Fuel type is a binary dependent variable. So, the regression here used is LOGIT regression, both for rural and urban areas separately.

Table 14: LOGIT regression results: Rural households

Dependent variable: Fuel Type (Clean=1, Dirty=0)

Number of obs = 47, 104, LR chi2(6) = 7788.34, Prob > chi2 = 0.0000

Log likelihood = -11258.838 Pseudo R2 = 0.2570

Independent variables	Coefficient	p-value
eduindex	2.18***	0.00
hsindex	-3.84***	0.00
htindex	-0.15***	0.00
mpceclass	0.86***	0.00
sexhh	0.38***	0.00
agehh	0.01***	0.00
Constant	-6.13***	0.00

*** significant as less than 1% level

Table 15: LOGIT regression results: Urban households

Dependent variable: Fuel Type (Clean=1, Dirty=0) Number of obs = 26,183, LR chi2(6) = 8940.85, Prob > chi2 = 0.0000Log likelihood = -11350.806 Pseudo R2 = 0.2826

Independent variables	Coefficient	p-value
eduindex	1.79***	0.00
hsindex	-3.68***	0.00
htindex	-0.47***	0.00
mpceclass	0.83***	0.00

sexhh	0.23***	0.00
agehh	0.01***	0.00
Constant	-2.02***	0.00

*** significant as less than 1% level

The results for the rural and urban area are shown in table 14 & 15 respectively. In both the cases the value of LR chi-square is significant making the entire regression meaningful. The regression analysis shows that education of the head of the household plays a significant role in determining the fuel choice. As educational attainment goes up the people become more aware of the harmful effect of the polluting fuels and therefore probability of making the choice of clean fuel increases. That explains the positive sign of the coefficient of the education index for both the regions. The result is significant. The index of house structure shows a negative sign with less than 1% significance for both rural and urban areas. This implies that higher the value of the index households become inclined to dirty fuel. This is expected as higher value of house structure index implies use of kutcha houses. Household type also has a negative coefficient for both the regions implying more use of dirty fuels by the household who are engaged in agriculture in rural area and by the households engaged in casual labour job in urban areas. Higher economic affluence reflected by the MPCE class increases affordability and therefore has a positive significant impact on the fuel choice. The more affluent the household is the more is the use of clean fuels in both urban and rural regions. Positive coefficient of sex of the household head implies that households with female head use more clean fuels than households with male heads. This may be due to the fact that females are more exposed to the indoor pollution when they cook and spend more time in front of the cooking hearth. So, they favour cleaner fuels and they enjoy more decision making power when they are the head of the household. Their choice no doubt goes in favour of cleaner fuels. Age of the household head also plays a significant role in determining the fuel choice. Aged heads chooses cleaner fuels as they become more experienced and hence more aware of the consequences of the use of dirty fuels.

Conclusion

The study shows that the education and income, among others are two most important determining factors of the fuel choice by the households. Income may also have an impact on the house structure as higher income implies higher affordability and hence house structure may improve. Increase and spread of education is need of the hour. It has the potential to raise the awareness level in the household heads as well as other members of the family. A basic education that makes people aware of the health effects caused by the polluting fuels may help in this situation. An awareness campaign spreading the information of

harmful effects of dirty fuels and benefit of using cleaner fuels may be helpful to bring a shift in the fuel choice. Education can also help when people do not use clean fuel even when they can afford the same, i.e., when the main impediment is some sort of cultural belief that stop the households from using cleaner fuels. Creation of employment opportunities in expectation of increasing the affordability of the cleaner fuels and better ventilation may be thought of as the long run policy strategy.

Conflict of Interests

The authors declare that there are no conflict of interests that are directly or indirectly related to this research work.

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