

Using Cheaper Firewood and Paying Higher Treatment Costs in a Rural Community

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Abstract

Health problem related to respiratory diseases is acute particularly in rural communities where firewood and agricultural residues are used as primary fuel. The use of inefficient traditional cookstoves in poorly ventilated rooms causes high levels of household air pollution, and also contributes to ambient air pollution. Household air pollution causes significant chronic health problems such as Asthma, COPD and Heart diseases, eye pain, head, and back pain as common diseases. This study aims to investigate factor affecting human health by using firewood in inefficient stoves and estimates the associated household health costs. A field survey was administered in 3 municipalities from two districts; Sindhuli and Kavrepalanchowk districts in between the years 2019 and 2020. A survey was carried out among 221 households. To gain deeper insights, we employed a cross-sectional analytical study, utilizing primary data and applying a multiple linear regression model. The findings show that there is a positive and significant relationship between health treatment cost and firewood use. This study recommends that cook stoves programmes should not be seen as only a means to reduce deforestation and time savings, but also need to be seen from health aspects in the rural households.

Keywords: health cost, treatment cost, firewood use, firewood cost, Household Air Pollution, regression analysis

1. Introduction

Two-third of Nepalese households are still using inefficient traditional cook stoves for cooking based on traditional biomass such as firewood, agricultural residue, and animal dung. Incomplete fuel combustion of solid fuels emits greenhouse gases (GHGs) and harmful smoke, not only contributing to climate change, forest degradation, but also increasing health related issues. The children, women, and the elderly are the most vulnerable to this disease because they spend the most time indoors. In order to enhance the overall health of entire household, it is important to minimize the sources of indoor air pollution by addressing its negative health impacts (Ahmed et al., 2019). Among all, the quality of life has been degrading due to use of inefficient traditional cook stoves. Household air pollution from household energy use is a major public health hazard for developing nations, including large numbers of the world's poorest, most vulnerable communities.

Household air pollution may possibly be to blame for the world's highest disease burden as health effects of household air pollution and some commonly related diseases due to its exposure include chronic obstructive pulmonary disease (COPD), lung cancer, reduced lung function, respiratory illnesses,

cardiovascular dysfunction, chronic bronchitis, eye diseases, pregnancy complications and weakening of the immune system responsible for a significant global health burden (Ahmed et al., 2019). In low-income countries such as Nepal, indoor air pollution, generated by the burning of biomass fuels, is the top-fourth risk factor driving overall morbidity and mortality (Ghimire et al., 2019).

Along with traditional cook stoves, households consisting of LPG stoves and mud improved stove are not used regularly. Likewise, with the lack of maintenance facilities available for mud improved stoves, people return to using tripod stoves. The easy supply of firewood’s from the private lands, preparation of livestock feed, behavior and community environment have not let to escape from using traditional stoves in households.

This paper quantifies the health treatment costs due to burning firewood and agriculture residue in traditional cookstoves. The linkages between the firewood use for long time and health outcomes is visible. The study explores that the firewood is almost free of cost and there is no alternative use of firewood other than burning is one of the major reasons to make it as a primary fuel. The lack of local markets and other provisions for firewood supply in city centers and no idea on demand also make people to use firewood. Additionally, lack of interest in installing Improved Cook stoves (ICS) and the use of other fuels as primary fuel due to low awareness level in effect of household air pollution on health and social behavior reluctant them to adopt. This paper provides an evidence-based insight into household air pollution, and its effect on health.

2. Review of Literature

2.1 Status of Household Air Pollution in Nepal

71.7 percent of the households in Nepal are connected to the national grid while 23 percent of households are using an off-grids (Micro Hydro, Solar Home Systems) sources to meet their lighting energy needs. About 5.2 percent of the households do not have electricity access in Nepal with majority of these populations living in most remote parts and with scattered settlements (The World Bank, 2019). There may be strong correlation between years of lighting and cooking, however detail study is demanded to make it empirically evident. Likewise, off-farm economy and rural-urban transition may be the resultant force for avoiding the traditional stoves.

In an average 68 percent of the population use firewood, out of which 58 percent use traditional stoves. The use of different stoves in province level is provided in Table 1. The use of traditional cookstoves is high in Sudhur Paschhim and Madesh province. However, in ground level use of traditional stoves is higher and HHs consists of more than one stove in the house but use of iron tripod cook stoves is commonly found in the rural HHs.

Table 1: Status of Clean Cookstoves and Fuel Access in Nepal

Provinces	Traditiona l stove	Improve d stove	Bioga s stove	Kerosen e stove	Solar Cooke r	LPG stove	Electric /rice cooker	Total
Koshi	58.2	9	2.2	0	0	30	0.6	100
Madesh	74.1	0	0.2	0	0	25.5	0.2	100

Bagmati	36.7	3.8	1	0.1	0	57.1	1.3	100
Gandaki	42.4	7.2	2.9	0	0	47.5	0	100
Lumbini	54	11.8	0.7	0	0	33.3	0.2	100
Karnali	59.2	27.9	0.8	0	0	12.1	0	100
Sudhur Pachim	80.1	6.9	2.8	0	0.1	10	0	100
Average	58	10	2	0	0	31	0	100

Source: Based on World Bank (2019)

Use of LPG fuel for cooking is increasing rapidly in road access areas. Tier rating of a stove is done based on efficiency, emission, safety, and durability. For each indicator, cookstoves are rated Tier 0 (lowest performing) to Tier 5 (highest performing) (Practical Action, 2021). Regarding the use of clean energy, at the national level lots of discussions and pilot projects for promoting electric cooking primarily in urban and peri-urban areas is happening.

Biomass Energy Strategy 2017 sets targets to provide at minimum Tier 3 clean cooking technologies to all households by the year 2030. It aims to enhance the living standards of people by modernizing the use of biomass energy through efficient use of biomass energy (GoN, 2017).

The study establishes that the mud ICS is an appropriate intervention to reduce PM_{2.5} and CO in rural kitchens (Singh et al. 2012). Similarly, the experiment done to determine whether a mechanical hood ventilation system can provide a significant improvement to indoor air quality concentration relative to natural ventilation without hood found that introducing proper mechanical hood ventilation (with a fan) in the kitchen can significantly improve indoor air quality in terms of PM_{2.5} and Carbon concentration (Chaudhary, et al., 2019). A study comprising the time, energy and cost required for using different types of cooking devices shows that electric induction cooker is the most cost effective and least time consuming device in the market (Shrestha et al., 2020). This shows that, the various types of cooking stoves and fuels that have been studied in local context are motivating to promote clean cooking energy.

Household Air Pollution needs to be reduced significantly through the adoption of clean cooking solutions. Reduction needs are recommended by the Air Quality Guidelines of WHO, defined as Tier- 5 by the International Organization for Standardization (ISO) in terms of emissions leading to direct exposure. The use of firewood in inefficient stoves with low income, low level of literacy rate and smoking habits combinedly affect human health. However, in reality, change in the cooking behavior of the rural communities is difficult unless it is not planned wisely and appropriately implemented.

2.2 Diseases related to air pollution

According to the report by Nepal Health Research Council 2016, households air pollutant parameters are associated for respiratory health, illness and deficits in lung function. Household air pollution is a major risk factor causing chronic obstructive lung disease in adult and acute respiratory infection in children.

According to State of global air 2020, long-term exposure to air pollutants causes some of the most serious impacts of air pollution globally. In terms of public health related diseases results in 40 percent of COPD deaths, 20 percent of diabetes deaths, 20 percent of ischemic heart diseases death, 19 percent of lung

cancer deaths, 26 percent of stroke deaths, 30 percent of lower respiratory infection deaths and 20 percent of neonatal deaths (State of global air, 2020).

The inefficient biomass cook stove technology is strongly linked to very high level of household air pollution (HAP), causing more than 22,500 premature deaths every year and loss of more than 710,000 disability-adjusted life years (DALYs) annually due to HAP (Practical Action, 2021). In 2019, 71.1% of all deaths in Nepal were caused by Non-communicable diseases (NCDs) and have emerged as the leading causes of death in both males (70.8%) and females (71.5%). Approximately 61.2% of total Disability-adjusted life year (DALYs) and 74.9% of total years lived with a disabilities (YLDs) were attributed to NCDs (DoHS, 2019/20).

Based on these solid evidence, the issues of public health should not be considered separately in plans and programs of the government. Consequently, Local Governments need to be more responsible for enabling cooperation between community actors, promoting public-private partnerships for local energy generation and management. Local government’s continuation for clean energy use need to engage from level of awareness and capacity building campaigns to promote private sectors in employment generation in the local level. In contrast, most of the local level suffered by lack of adequate human resources with relevant skills and clear responsibility for reliable clean energy promotion.

While conducting the field study, it was apparent that Asthma were more prevalent among the households surveyed. Upon observation and analysis, it was found that these illnesses were occurring with a higher frequency than others. Specifically, the following major illnesses were identified as being the most prevalent during the survey period as provided in Table 2.

Table 2 Major illness in the study area

S.N.	Major illness	Frequency (%)
1	Asthma	90 (40.75)
2	Chronic obstructive pulmonary disease (COPD)	57 (25.8)
3	Heart related diseases	24 (10.85)
4	Headache	9 (4.1)
5	Eye pain	23 (10.3)
6	Backpain	9 (4.1)
7	Others	9 (4.1)
Total		221 (100)

Source: Field survey, 2020

Among the respondent’s households, the chronic diseases were related to asthma in 40.75 percent, chronic obstructive pulmonary disease (COPD) in 25.8 percent and Heart related diseases in 10.85 percent. Other temporary type of ailments related with headache in 4.1 percent, eye pain 10.3 percent, back pain in 4.1 percent, headache and back pain in 4 percent respectively.

3. Data and Methods of the study

The research method involved households during pilot survey in which household’s respondents reported on recent illness of one of the HH member related to household air pollution during 2019-20. The

secondary information was collected from desk review of policy documents, plans, programme reviews, impact studies and other published reports. The findings of the study are based on primary data collected from 221 households, five Focus Group Discussions (FGDs) and three Organizational consultations with organizations involved in energy and health sector. Primary data were collected from three municipalities, out of which field survey was administered in Marin of Sindhuli district and Bethanchowk and Temal of Kavrepalanchowk district. A survey was conducted in 221 HHs randomly selected households in Sindhuli and Kavrepalanchowk districts during 2019- 2020 for project development in health and energy sector. The study was able to capture the nature of household air pollution related to firewoods and associated health problems reported by the households.

The medical consultation cost was estimated on the basis of registration fee to check up with Medical consultants in government and private hospitals of Kathmandu. The medical travel cost was estimated based on the respondent's monetary travel cost to visit health post, government and private hospitals for treatment. The treatment cost was estimated on the basis of the frequency of visit for consultation, fees for admission and medicines cost during hospital stay, regular medication for treatment. As the health of the family members was affected negatively by fuelwood use in inefficient cookstoves and inadequate cross ventilation in the household, we consider most affected HH member suffering from illness and the treatment cost during the period of one year. The data analysis was carried out by using multiple linear Regression using R programming.

Calculating health costs and firewood costs

The household survey was also used to assess the prevalence of major illnesses Asthma and chronic obstructive pulmonary disease (COPD), Heart Problems and minor illness related to head and back pain, and eye pain mostly prevalent diseases among the respondents during information collection and are related to smoke inside the home. COPD was the most serious and more time taken diseases with few pneumonia cases, however detail investigation was not done in this study. In order to calculate the economic impact of health problems on households with individuals suffered from above mentioned diseases, respondents were asked how much HHs had actually spent on medical and other associated during hospital visit, and hospital admit period. These costs include the costs of medicine, costs of diagnostic tests including X-ray and laboratory, fees charged by the doctor consultations, hospitals hospital stay charges.

Average daily household firewood consumption was estimated to be 12 kg, which gives average annual consumption of 4320 kg per household. Total fuel wood expenditure is based on the charge levied by Community Forest during collection time. This shows that fuel wood costs not more than NPR 2 per kg. However, the fuel wood used by the HHs are collected from own private lands with free of cost and time value has been underestimated in the study.

Due to limited nature of the study, nature of medication time period and additional dietary expenses needed for certain illness for long period were not assessed. The health effects of burning firewood were estimated based on the respondent's view and the health costs were gathered at the household level.

Empirical Framework for Health Costs Estimation

The explanatory variables used for hypothesis testing were grouped into three categories: (1) Type of fuel use type (2) household characteristics (age, gender, number of HH members) (3) habits (smoking). Type of stoves and amount of Fuel Use was hypothesized that the use of high amount of fuel woods in tripod stove increased the health problems. The more food to be cooked in larger amount need large amount of fuel, which would be a typical experience of larger families. An absence of separate kitchen from the dwelling room was observed during survey. The houses that were built after earthquake in year 2015 commonly consist of one or two rooms. It was also hypothesized that higher number of HH members need high amount of firewood associated with higher health cost. As women spend more time indoor than their male counterparts, it was hypothesized that women would suffer more from the smoke as compared to men. Subsequently, the health problems were hypothesized to be lower among the households with the use of lower cost of fuel wood. Smoking habit was taken as yet another confounding factor that was believed to cause respiratory health problems. However, Passive smoker is not included in the model.

Model Design

This study’s purpose to measure the effect of use of firewood as fuel on the medical treatment cost. Thus, the dependent variable of the study is Treatment cost which is measured by yearly medical expenses for the treatment and independent variable of the study is Firewood, which is measured by yearly firewood expense incurred by the family. Similarly, other independent variable is Age, smoking habits, gender number of household members, Health institution, medical consultation charge, and medical travel cost. Here, Gender, smoking habits and health institutions are refereed as categorical variables. Gender represents whether the patient is male or female and female is selected as reference group. Similarly Smoking habits variable represent whether the patient is smoker or non-smoker, and non-smoker is selected as reference group. Likewise, Health institutions represent a place where patients receive his/her treatment such as health post, public hospital, and private hospital. Here, Health post is selected as reference group. Thus, this study sets the following multiple linear regression model:

$$\text{Medical expenditure}_i = \alpha_i + \beta_1 \text{Age}_i + \beta_2 \text{Smoker}_i + \beta_3 \text{Public Hospital}_i + \beta_4 \text{Private Hospital}_i + \beta_5 \text{Advicecost}_i + \beta_6 \text{Travel}_i + \beta_7 \text{Firewood}_i + \beta_8 \text{Female}_i + \beta_9 \text{Household}_i + \mu_i \dots \dots \dots (1)$$

where,

Medical expenditure: family medical expense for treatment per annum.

Age: Age of patient

Smoker: Patient who are smoking

Public Hospital: Patients who have received treatment at public hospital

Private hospital: Patients who have received treatment at Private hospital

Advice cost: Medical consultation charge per annum

Travel: Medical travel cost per annum

Firewood: Cost of firewood incurred by family per annum

Female: Female patients

Household: Number of family members

μ_i : Error term

4. Results and Discussions

Cost of Household Air pollution

During Household survey, Asthma and COPD is a relatively costly health problem. The consultation fees ranges from free service in health post to maximum NPR 1500 in hospitals. Likewise, treatment cost ranges from free medicines to maximum NPR 7,50,000, which includes hospital admission and long stay in hospital. Similarly, the travel cost related to visit hospitals in city areas cost around NPR 2,50,000. The average cost of travel amount is NPR 8,898. Using the information gathered on health costs, it is estimated that the average treatment cost of for households in rural area is about NPR 60,666 per annum. The survey underestimates the health impact of HAP in long term and mortality.

While estimating the average expenditure of household for firewood is NPR 8,652 per annum using open firewood stoves. Though, the household consists of LPG and use is limited. If the HHs uses the LPG for whole year, it would cost NPR 14,000 per annum, which includes NPR 3200 of one-time investment. So, the fuel expenditure is only NPR 10,800 per annum, which is not so costlier even in monetary value than firewood use. However, overall health benefits exceed too much for firewood used in kitchen.

Therefore, further research is needed to get an exact valuation of the impact of HAP on rural communities and the market valuation for different kinds of firewood. However, by using this study’s health cost figures the cleaner cooking techniques can reduce household health costs significantly.

Descriptive characteristics of respondents

The descriptive statistics of the variables used in the model for estimating the health effects on the individual family members in household are presented and described in Table 3.

Table 3 Descriptive characteristics of respondents and households’ characteristics

Characteristics	N	Max	Min	Mean	S.D.
Age of Patients in HH	221	99	5	53	17.5
Average HH Income	221	600,000	300,000	360,000	10,000
Years of schooling HH head	221	10	0	4	3
Number of HH member	221	13	1	4.3	1.9
Hours cooking per day (in hours)	221	8	1	3.5 hrs	1.3
Number of meal in a day	221	6	2	3.3	1.8
Medical consultation cost (NPR)	221	1500	20	447	358
Medical Travel cost (NPR)	221	2,50,000	0	8,898	30,298
Treatment cost (NPR)	221	7,50,000	0	58070	10,727
Annual Firewood expenditure (NPR)	221	60,000	1,000	8,652	6,685
Years of Grid connection	221	7	1	3.2	1.8
Years of LPG use	172	20	0	6.5	4.4

Source: Field survey, 2020

The study able to capture the health problems in the household member related to Household Air pollution within one year. 44 percent of female and 32 percent of male are suffered from Asthma. Likewise, 21 percent of female and 35 percent of males were suffered from COPD.

According to respondents, the diseases diagnosed in the hospital are obviously linkage to household air pollution, however it is not clear from the informants about the severity of the disease. The information shows that the patients came from the households using firewood’s for cooking and HHs consist of LPG in their kitchen are similar as LPG is rarely used i.e. to prepare tea for guests and emergency case.

The respondents are found aware in treatment to health post or hospitals when they suffered from diseases. At first, they go to Health post for primary care. In the study, around 65 percent of patients visited health post for treatment. Likewise, 5 percent of patients visited government hospital while 30 percent visited private hospital. It was found that when the patient condition is serious, patients were taken to private and government hospitals in city areas. Basically, the selection of hospital depends upon the choice of relatives residing in city centers. The medical travel cost is higher when the patient is serious and taken to hospitals through Ambulance service.

Based on the empirical data and the regression method mentioned above, we examine the relationship between household medical expenditures (treatment cost) and expenditure on fuel wood, considering the effects of household characteristics and other variables. The empirical baseline regression on Multiple linear regression estimation model is provided in the Table 4.

Table 4 Result of Multiple Linear Regression

Dependent Variable: Medical Expenditure	
Age	1,388.404*** (275.240)
Smoker	41,581.380*** (10,001.250)
Private Hospital	77,075.820*** (17,850.180)
Public Hospital	11,501.560 (25,585.500)
Advice cost	98.312*** (25.538)
Travel cost	0.764*** (0.161)
Firewood cost	6.629*** (0.531)
Female	15,319.120 (10,345.830)
Household member	3,288.525 (2,479.374)
Intercept	-153,473.700***

	(24,250.100)
Observations	221
R²	0.621
Adjusted R²	0.605
Residual Std. Error	67,423.970 (df = 211)
F Statistic	38.439*** (df = 9; 211)

Note: *p<0.1; **p<0.05; *p<0.01**

In the multiple linear regression model, after controlling the household characteristics and other variables, the coefficient of Firewood is positive indicating there is a positive relationship between medical expenditure and firewood cost which means using firewood for fuels has a heavier medical expenditure for treatment. Keeping other factors constant, the coefficient of firewood cost (6.629) indicates the treatment cost on average is expected to increase by NPR 6629 per annum when the firewood cost increases by NPR 1000 annually. Further, the p-value of the firewood indicates the statistically significant relationship between medical treatment costs and firewood costs. Similarly, the coefficient of age (1388) is positive indicating as the patients gets older, their treatment cost also increases i.e., treatment cost on average is expected to increase by NPR 1388 per annum for each additional age of the patients, keeping other factors fixed. The p -value of age indicates significant relationship between age and treatment cost. The treatment cost reported by female is higher compared to male, however it was not found statistically significant. Likewise, the positive coefficient of a smoker indicates smoker incurs more treatment cost compared to a non-smoker, i.e., the treatment costs for a smoker on average is NPR 41,581 per annum higher than a non-smoker, keeping other factors constant. Further, a P-value indicates a significant relationship between the smoking habits of patients and treatment costs.

The treatment cost is also influenced by the health institution in which patients received their treatment. Health posts and public hospitals are considerably cheaper than private hospitals. The coefficient of the private hospital (77,075) indicates the treatment cost at a private hospital is expected to be higher than the health post i.e. on an average treatment cost at a private hospital is NPR 77,075 per annum higher than health post, keeping other factors constant, Likewise, the public hospital cost is expected to be higher by NPR 11,501 than the health post, however not statically significant. Likewise, there is a positive and significant relationship between treatment cost and travel cost and consultation charge i.e., as travel and consultation charge increase, treatment cost also increases. The coefficient of travel cost (0.764) indicates that keeping other factors fixed, medical expenditure on average is expected to be increased by NPR 764 annually when travel cost for treatment increases by NPR 1000 per annum and the coefficient of advice cost (98.31) from Medical Consultant indicates NPR 100 increase in advice cost annually increases treatment cost by NPR 9,831 per annum, keeping other factors fixed. Likewise, there is a positive and significant relationship between number of member in the household and treatment cost. i.e. one additional member expected to increases the treatment cost on average annually by NPR 3,288 keeping other factors constant. However, there is no statistically significant relationship between the household member and treatment cost.

Finally, the R square of 0.621 or 62.1% indicates, 62.1% of the variation on treatment cost are explained by independent variables.

Conclusions

The study uses micro-level data to examine the relationship between firewood use in inefficient cookstoves and the burden of medical expenses in households. The results show that the use of firewood in open fire stoves will increase the burden of family medical expenses.

This study explores the fact that the lack of market for firewood and lack of commercial use of firewood obtained from their private land and nearby forest with free of cost influence them to use it. However, the lack of effective clean cooking programs and implementation of externally built and supplied ICS in the kitchen seems ineffective.

In comparison to educated and migrated communities, rural households' behavior and their livelihood based on livestock rearing and the requirement of tree management in private lands show that people are using inefficient stoves and fuels. The use of firewood is decreasing with migration in roadside areas and engaging in off-farm occupation.

The local government needs to mobilize Female Community Health Volunteers (FCHVs) health workers and mother groups in community-based outreach programs to deliver counseling and general support as part of clean energy programs. FCHVs can play a critical role in educating community members on the user benefits of clean cooking solutions as well as delivering clean cooking devices to households. HHs need to be aware of greater medical expenses due to the use of firewood with inefficient stoves. Therefore, the delivery message of using the clean fuels that can benefit health and save money overall along with desired solutions for community energy demand for cooking is needed. The three tier of government (Federal, Province, Local) could provide appropriate subsidies to allow more residents to use clean fuels and improve resident's welfare.

Based on the limited household survey data, the study identifies the primary cooking fuel is still firewood used by the households in rural areas based on agriculture and livestock rearing. The study findings show that there is an association between an increased amount of fuel woods with long -time exposure and illness with high amount of fuelwood use. In addition, the study has not considered the detailed health status and genetic illness of family members, so detailed results could not be expected. Moreover, it is concluded that the benefits of promoting clean fuels outweigh the cost of health expenditure. However, in the process of promoting clean fuels, local people need to be involved in order to choose the efficient cook stoves, further research is needed on rural households in the demonstrative form in order to promote clean cooking stoves more effectively. The rural community demands the technology such that wood and other biomass fuels can be burned effectively with low emission at home or the easy access to fuelwood market for selling their fuelwoods from their own lands. If it is possible, then only it can play a long-term role in sustainable development. The commercial use of firewood for industrial use in efficient way would be necessary for marketing the firewood materials such that rural people can earn and shift to clean cook stoves.

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