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Burning for Survival: Health Risks of Traditional Cooking Fuels for Tribal Women in Lahaul and Spiti, India

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Abstract

Introduction: The lack of access to clean fuel in tribal and remote villages significantly worsens the health of females and children due to prolonged exposure to smoke from burning solid fuels such as wood, dung, and crop residues.

Objectives: The present study aims to examine the use of solid fuels and their detrimental impact on the health of tribal women, while also identifying the barriers hindering the adoption of clean cooking fuels such as LPG.

Material and Methods: A collection of 480 women was surveyed from remote villages of Lahaul and Spiti with the help of structured questionnaire. Descriptive statistics and logistic regression were applied to find out the determinants of risk factors and its association.

Results: Of the 480 women participants, 75.2% were ever exposed to unclean fuel while cooking and only 24.8% used clean fuel. Women respondents reported various health problems while using unclean fuel in open cookstoves- skin infection (48.5%), respiratory infection (46.9%), dry eyes (41.3%) and cardiovascular problems (17.1%). Odds of use of unclean fuel were significantly higher among poor (AOR=3.09, CI=1.14-5.11, $p<0.05$) and homemaker (AOR=2.54, CI=1.13-4.51, $p<0.01$) female participants and suffering from various health infections- skin, respiratory, eye, cardio and common cough.

Conclusion: Free availability of firewood and agriculture waste, high initial cost of LPG, refill cost of LPG, disruptions in supply chain and lack of awareness about adoption of clean fuel in the remote villages were the major barriers towards the adoption of clean fuel. Targeted interventions that address affordability, ensure reliable access, and incorporate local awareness programs are essential for broader transition to clean energy source in tribal and remote areas.

Keywords: Usage of Solid fuel, Barriers towards adoption of LPG, Tribal females, Lahaul & Spiti, India

Introduction

Around two-third of Indian households continuously depend upon different sources of traditional and unclean fuel for cooking.[1] Although, India is stepping towards clean energy transition and providing affordable and cleaner energy to the households through various targeted subsidized programs. Yet, access to cleaner energy is a faraway dream for rural households particularly in remote regions. According to NFHS5 report 2019 -21, 51.7% households use clean fuel for cooking in Himachal Pradesh and 47.7% still utilize unclean biomass for cooking.[2] Furthermore, out of all types of solid biomass, wood is highly used by women in open cookstoves in Himachal Pradesh (47.5%) [2]. Several studies had indicated the significant linkage of use of biomass in kitchen and indoor air pollution. To provide a safeguard for the health and environment, Government of India has launched the PM Ujjwala Yojana scheme in May 2016 to provide free LPG cylinder to poor families and stated that 94% households have now LPG connection. [3] World Health Organization report on household air pollution and health (2015) reported that half of under-five mortalities in world is due to the pneumonia caused by particulate matter.[4] As per the fact sheet of WHO (2022) household air pollution is responsible for 3.2 million deaths in 2020 and women and children bear heavy burden of dangerous cooking.[5] The exposure of indoor air pollution due to burning of solid biomass is particularly high among women and children who spend most of the time near open cookstoves.[6] The inefficient combustion of biomass have long term exposure to toxic pollutants like fine particulate matter (PM) and carbon monoxide which further associated with high incidence of respiratory infection, chronic lung disease and cancer.[7]. India faces a significant challenge in providing clean energy to every household but as per the projections of international energy outlook, India will not fulfil the targets under 7.1 Sustainable Development Goals (SDGs). By 2030, 39% Indians still rely on biomass for cooking.[8] Clean energy technologies and methods are relatively expensive as compared to traditional biomass. The behaviour of consumers plays a vital role in clean energy transition whether they want to spend more on clean fuels and have awareness about dangerous effects of solid fuels.Umpteen studies are available in relation to use of solid biomass and health problems in different regions and countries. None of study is found on this aspect particularly for Lahaul and Spiti district, Himachal Pradesh. In the above background, the current study is aimed to explore the utilization of solid cooking fuels and its association with different health problems faced by tribal females, along with barriers towards to adopt clean cooking fuel in remote villages of Lahaul Spiti, Himachal Pradesh. The strength of the study is covering of tribal females of hilly remote region of Lahaul and Spiti valley that is also High Priority District of Himachal Pradesh. Moreover, the study is analysing the impact of use of solid cooking fuel and its related health problems among tribal females. The study also concentrates on the barriers towards the use of LPG adoption in their homes.

Literature Review

The use of solid cooking fuels such as wood, charcoal, cow dung cakes is strongly associated with a range of adverse health effects [9]. Existing literature reveals a consistent and negative association between the use of traditional fuels and health problems. Large-scale prospective studies, such as the PURE study involving over 91,000 adults across 11 countries, had found that households using solid fuels for cooking face increased risks of all-cause mortality, cardiovascular disease, and respiratory diseases compared to those using clean fuels like electricity or gas. Specifically, hazard ratios for all-cause mortality, cardiovascular disease, and respiratory disease were all elevated among solid fuel users and Household Air Pollution (HAP) is a major risk factor for chronic disease [31]. A longitudinal study from China supports above findings, showing that solid fuel use for either cooking or heating is linked to higher all-cause mortality and greater risk was observed among those using solid fuels for both purposes simultaneously [32,33]. Combustion of these fuels releases harmful pollutants, including particulate matter, nitrogen oxides, benzene, formaldehyde, and carbon monoxide, which contribute to increased risks of respiratory diseases like tuberculosis, chronic obstructive pulmonary disease (COPD), asthma, and acute lower respiratory infections [8]. These health risks are especially pronounced among women and children, who spend more time near cooking areas and are thus more exposed to toxic smoke [30,34]. The literature consistently emphasizes that the health burden from solid cooking fuels is substantial and that promoting cleaner alternatives is critical for reducing morbidity and mortality, especially in low- and middle-income countries where reliance on solid fuels remains high [35].

Material and Methods

Study design and Area

The current study is community based and cross-sectional study conducted among tribal females in remote villages of Lahaul and Spiti district, Himachal Pradesh. Lahaul and Spiti is the largest district by area in Himachal Pradesh, India, located in the northern Himalayas at coordinates approximately 32°30′N 77°36′E. The terrain is mountainous and consists of two distinct regions: Lahaul, known for its green valleys like the Chandra, Bhaga, and Chandra-Bhaga valleys, and Spiti, a high-altitude cold desert with an average valley floor elevation of 4,270 m (14,010 ft). According to the Census of India 2011, the district Lahaul and Spiti comes under the Trans-Himalayan zone and is situated in the northeastern

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part of Himachal Pradesh. The district is divided into three main subdivisions – Keylong (Lahaul), Kaza (Spiti), and Udaipur, and on the basis of community development blocks, it is divided into parts – Lahaul Valley and Spiti Valley. The district Lahaul and Spiti has a rural population 31,564, and the total villages belonging to Lahaul and Spiti Valleys are 231 including inhabited and uninhabited.[10] The harsh aspect about the Lahaul and Spiti is the district is cut off from the rest of the world from November to march due to heavy snowfall and severe climatic conditions. Therefore, the widen research gaps are present for this remote and high-priority district of Himachal Pradesh.

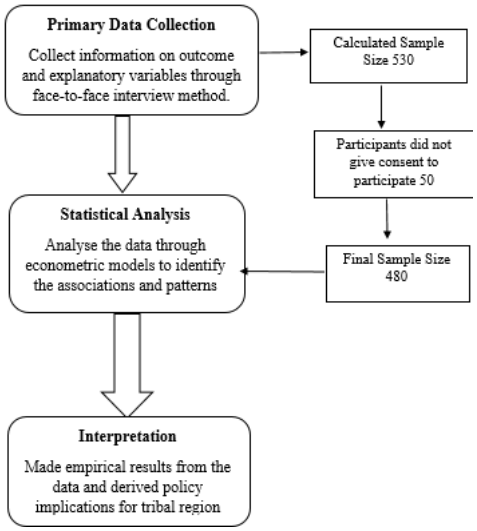
Study Sampling Framework

In sampling framework, sample size for current study was computed by single proportion formula:

$n = Z^2 P (1-P)/ d^2$

where n is sample size here and z is the statistics corresponding to 95% level of confidence. P is the expected prevalence of the key variable and d is the precision level or taken as margin of error. In current study, value of P is 72% [2] shows the proportion of households using unclean fuel and 5 % margin of error corresponding to 95% CI. By using this formula, the calculated sample size was 482 and including 10% non-response rate. Hence the final sample size was 530. Households were selected through two stage random sampling technique. At the first stage of sampling, Lahaul and Spiti district was selected due to High Priority District of Himachal Pradesh. At second stage, on the basis of population parameter, high populated villages were taken out from Lahaul division and Spiti division. A total of seven villages from both development blocks- Keylong, Jispa, Koksar, Udaipur, Triloknath, Kaza Khas and Kaza Soma were selected to identify the households. At last stage, female respondents were chosen from sampled villages through random number tables. A total of 480 women was interviewed through structured questionnaire after getting their consent to participate in the research. Rest of the participants did not give consent to participate in the study

The presentation of research framework of the current study is shown in figure 1



Statistical Analysis

Data analysis was done with the help of RStudio Team (2020). RStudio: Integrated Development for R. PBC, Boston. To carry out empirical analysis, descriptive statistics – mean and percentages were computed. Later on, Principal Component analysis was used to calculate wealth quintiles for each respondent and classified into three categories- rich, medium and poor. Bivariate and multivariate logistic regression technique were employed to determine the association between health problems and use of unclean fuel through odds ratio. Crude odd ratio and adjusted odd ratio were computed at 5 % significance level in this study and findings were based on adjusted odds ratio (95% CI). Logistic regression goodness of fit was tested by Hosmer and Lem show test based on chi square, indicates good fit ($p > 0.05$).

Mathematically, the logistic regression model can be explained as:

$P=E\ (Y = \frac{1}{X_k})$

Or

$P= b_0+ b_1X_1 +b_2X_2+$_____$+b_kX_k$

It can be rewritten as for one predictor variable

$P(y) = \frac{1}{1+e^{-(b_0 + b_1X_1)}}$

For multiple explanatory variables

$P(Y) = \frac{1}{1+e^{-(b_0 + b_1X_1 + \text{----------} + b_k X_k)}}$

$P(Y) = \frac{1}{1 + e^{-z_k}}$

Or $P = \frac{e^{z_k}}{1 + e^{-z_k}}$

Where $Z_k = b_o +b_1 X_1 + \text{------} + b_kX_k$

P is probability of occurrence of event and (1-P) is the probability of non-occurrence of event.

$P(Y) = e^{z_k}$

1-P(Y)

For obtaining outcome, Take Log on both side

$\alpha_k = ln\left(\frac{P(Y)}{1-P(Y)}\right)$

Study variables

In this study, the outcome variable is use of unclean fuel or any solid biomass during cooking which is binary in nature and coded as 1= use of unclean fuel and 0= use of clean fuel. Various independent variables were taken into consideration such as demographic variables- age, education status, occupation status and wealth status. Variables on cooking practices- type of cooking fuel, separate place of kitchen, daily exposure to solid fuel and duration of solid fuel use were also recorded. Furthermore, self-reported health problems reported by study participants were noted and classified into five categories with two responses- 'Yes or No'.

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Results

Table 1: Descriptive Statistics of study participants of Lahaul and Spiti, Himachal Pradesh (n=480)

Variables	Coding	Frequency (%)
Age in years	20-30	256 (53.4%)
	31-40	184 (38.3%)
	41-50	40 (8.3%)
Education level	No education	105 (21.9%)
	Grade 1-5	120 (25%)
	Grade 5-12	195 (40.6%)
	Graduation and above	60 (12.5%)
Occupation level	Homemaker	326 (67.9%)
	Daily wager	99 (20.6%)
	Salaried	55 (11.5%)
Wealth status	Poor	206 (42.9%)
	Medium	159 (33.2%)
	Rich	115(23.9%)

Source: Authors Elaboration based on Field Survey

Table 1 describes the baseline characteristics of study participants of remote villages of Lahaul and Spiti, Himachal Pradesh. A total of 480 tribal females had randomly picked and participated in the present study. Out of 480, 256 belonged to 20-30 years of age (53.4%), 184 belonged to 31-40 years of age (38.3%) and 40 belonged to 41-50 years of age (8.3%). The mean age of study participants was found 26.9 years Regarding the literacy level of the participants, majority of female respondents ranged in grade 5-12 (40%), followed by grade 1-5 (25%) and graduation and above (12.5%). In our study, 22% respondents were found completely illiterate. Female participants were categorized into homemaker (n=326, 67.9%), daily wagers (n=99,20.6%) and salaried monthly (n=55,11.5%). Of the surveyed households, majority of study participants belonged to poor class family (42.9%) and one third belonged to medium class families (33.2%). Only 23% female participants belonged to rich families.

Table 2: Distribution of study participants according to usage of different cooking fuels and practice (n=480)

Type of cooking fuel	Frequency (%)
LPG only	119 (24.8%)
Solid biomass only	136 (28.3%)
Mixture of LPG and solid biomass	225 (46.9%)
Place of kitchen	
Separate	138 (28.8%)
Inside the room	96 (20%)
Outside the room	246 (51.2%)
Duration of solid biomass use	
<5 years	124 (34.3%)
>5 years	237 (65.7%)
Daily time spent with open cookstoves	
30 Minutes	23 (6.3%)
1-2 Hours	167 (46.3%)
>2 Hours	171 (47.4%)

Source: Authors Elaboration based on Field Survey

Table 2 shows the distribution of study respondents as per the utilization of cooking fuels. Of the 480 study participants, 225 respondents were doing fuel stacking- utilize a mixture of LPG and Solid biomass (46.9%). 24.8% respondents reported about use of clean fuel and 28.3% used only solid biomass or traditional fuels. On cumulative basis, 361 female respondents ever exposed to unclean fuel in this study (75.2%). On the other hand, 51% female respondents cooked outdoors without any separate kitchen. Most of women respondents cooked outdoor had traditional firewood cookstoves. 28% women participants had separate kitchen in their houses and cooked food in the kitchen. only 20% women participants cooked food inside the living room or bed room (n=96). On analyzing the cooking practices among study participant, 480 women respondents involved in cooking presently. Of 480 participants,237 (65.7%) women were involved in cooking practice more than 5 years while rest of them 124 (34.3%) were doing cooking less than 5 years. The mean years of use of solid biomass among study participants were found 7.1 years. Out of 361 study participants using solid biomass, 47.4% female spent more than 2 hours in front of open cookstoves and 46.3% women spent 1-2 hours daily. The mean time spent by study participants with solid biomass was found 2.2 hours.

Table 3 Major self-reported Health Problems by women respondents (n=480)

Health Problems	Frequency (%)
Skin infection	233 (48.5%)
Lower respiratory infections	225 (46.9%)
Common eye infection	198 (41.3%)
Chronic obstructive pulmonary disease	94 (19.6%)
Cardiovascular diseases	82 (17.1%)

Source: Authors Elaboration based on Field Survey

In the current study, the self-reported health problems stated by study participants were categorized as- skin infections, lower respiratory infections, common eye infection, chronic obstructive pulmonary disease and cardiovascular diseases and described in table 3. Of the study participants, 48.5% reported various dermatological infection while cooking the food- bruises, skin burn and red rash (n=233). Similarly, 46.9% women respondents suffered from lower respiratory infections like cough, running node, nasal congestion and dry cough. 41.3% women suffered from common eye infections, 19.6% respondents reported COPD and 17.1% had problem of cardiovascular. Hence, the burden is especially severe for tribal females, as they spend extended hours each day cooking in smoke-filled environments and exacerbating their exposure to harmful pollutants. Figure 2 demonstrates various barriers in the path of adoption of clean fuels cited by tribal females of Lahaul and Spiti region. The primary reason for non-adoption of clean fuel was found high initial cost of LPG cylinder (53.3%) followed by loss of taste of food (45.1%). In addition to this, 42.6% tribal females reported about potential disruptions in supply of LPG in hilly terrains and 25.9% found hardships to refill the cylinder on time. Due to easy availability of firewood, dry shrubs and cow dung cakes in hilly terrain, tribal females were use solid fuels instead of clean fuel. The other barrier cited by tribal females was that lack of awareness about health benefits with adoption of cleaner fuel (23.8%) whereas 17.6% females reported that they did not know the harmful effect of solid fuel on health. Only 5.8 % tribal females cited social,

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custom barriers and misconception toward use of LPG for cooking. Hence, the adoption of clean fuels like LPG in tribal areas of Himachal Pradesh, such as Lahaul and Spiti valleys, faces several significant barriers. Affordability to clean fuel, Physical accessibility, cultural preferences and availability of free biomass, low education and awareness level were found as major and challenging obstacles among tribal households in Lahaul and Spiti.

Figure 2: Barriers toward adoption clean fuel among tribal females

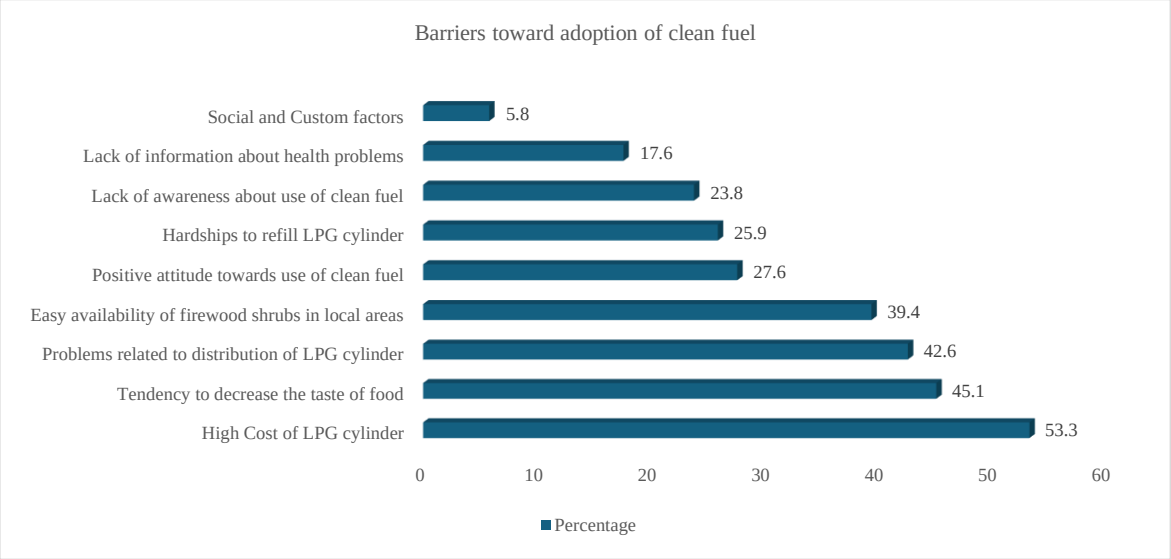

Table 4 Bivariate and Multivariate logistic Regression analysis of socio-economic variables and health problems with usage of unclean fuel (n=480)

Variables	Coding	Exposed to unclean fuel		Crude Odd Ratio (95% CI)	Adjusted Odd Ratio (95% CI)
		Yes (n=361)	No(n=119)		
Wealth quintiles	Poor	180 (37.5%)	26 (5.4%)	3.41 * (1.26-4.80)	3.09 ** (1.14-5.11)
	Medium	134 (27.9%)	25 (5.2%)	2.82 * (1.77-4.21)	2.67 ** (1.43-4.55)
	Rich	47 (9.8%)	68 (14.2%)	1	1
Occupation level	Homemaker	278(57.9%)	48 (10%)	2.96 ** (1.33-4.08)	2.54* (1.13-4.51)
	Daily wager	71(14.8%)	28 (5.8%)	1.69 ** (1.47-3.88)	1.28 * (1.03-3.57)
	Salaried	12(2.5%)	43 (9.0%)	1	1
Education status	Illiterate	93(19.4%)	12 (2.5%)	3.72 ** (1.84- 4.99)	3.41 * (1.67- 4.45)
	Grade 1-5	100(20.8%)	20 (4.2%)	2.11* (1.62-5.73)	1.94* (1.35-4.71)
	Grade 5-12	144(30.0%)	51 (10.6%)	0.82 (0.55-3.81)	0.44 (0.10-2.47)
	Graduation	24(5.0%)	36 (7.5%)	1	1
Skin infections	Sufferers	220(45.8%)	13 (2.7%)	4.87 * (1.89-6.12)	4.62 * (1.47-6.91)
	Non sufferers	141(29.4%)	106 (22.1%)	1	1
Lower respiratory infections	Sufferers	20141.9%)	24 (5.0%)	3.64 ** (1.54-4.21)	2.85 ** (1.20-4.66)
	Non sufferers	160 (33.3%)	95 (19.8%)	1	1
Common eye infection	Sufferers	190 (39.6%)	8 (1.7%)	3.02* (1.17-5.91)	2.94 * (1.05-6.08)
	Non sufferers	171 (35.6%)	111 (23.1%)	1	1
Chronic obstructive pulmonary disease	Sufferers	65(13.5%)	29 (6.0%)	2.15 * (1.29-3.58)	1.93* (1.55-4.05)
	Non sufferers	296(61.7%)	90 (18.8%)	1	1
Cardiovascular disease	Sufferers	61(12.7%)	21 (4.4%)	4.98* (1.14-7.35)	4.24 * (1.07-8.62)
	Non sufferers	300 (62.5%)	98 (20.4%)	1	1

Source: Authors Elaboration based on Field Survey

Note: 1 reference category, * 5% significance level, ** 1% significance level, CI confidence interval

The results of bivariate and multinominal logistic regression analysis of various independent variables to use of unclean fuel was elucidated in table 4. Odds ratio of both binominal and multinominal model show significant association of utilization of solid biomass with respect to socio economic and health status of tribal females. Being ever exposed to solid cooking fuel was significantly associated with wealth status of female participant. The odds of poor income class female had 3.09 times more probability to use unclean fuel (CI=1.14-5.11, $p<0.01$) followed by medium income class female (AOR= 2.67, CI=1.43-4.55, $p<0.01$) as compared to female belonged to rich income class. The likelihood to use unclean fuel was found more among homemakers (AOR= 2.54, CI=1.13-4.51, $p<0.05$) and daily wager female respondents (AOR= 1.28,

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CI=1.03-3.57, p<0.05) as compared to salaried class females. Odds of use of unclean fuel was found more among illiterate women (AOR=3.41, CI=1.67- 4.45, p<0.05) followed by grade 1-5 (AOR=1.94, CI=1.35-4.71, p<0.05) as compared to graduate women participants. In case of health status of female participants, being exposed to solid biomass was significantly associated with skin problems among female respondents (AOR=4.62, CI=1.47-6.91, p<0.05). The likelihood of being respiratory infections was 2.85 times more among female respondents who used solid cooking fuel (CI=1.20- 4.66, p<0.01). Ever exposed to solid fuel was also significantly associated with common eye infection (AOR=2.94, CI=1.05-6.08, p<0.05), chronic obstructive pulmonary disease (AOR=1.93, CI=1.55- 4.05, p<0.05) and cardiovascular disease (AOR=4.24, CI=1.07-8.62, p<0.05). Hence the risk of different health problems and infection was found more in study participants who ever exposes to unclean biomass. On bivariate analysis and multivariate analysis, study participants with health diseases showed significant association with use of unclean fuel.

Discussion

The current study analyses the risk factors of using solid biomass fuel for cooking among tribal women in Lahaul Spiti. Out of 480 study participants, majority of tribal females used mixture of solid biomass and LPG (46.9%), 28.3% used solid biomass only and 24.8% utilized LPG for cooking and in line with study conducted in India by Ranjan et al. [9] High-end use of solid fuel was found more among less educated and homemaker women participants due to idle time for cooking. [10,11] Afridi Farzana et al concluded that time saving behaviour among women can make a dramatic shift toward clean energy and fall in health burden.[12] Carlos and Johannes studied that educational achievement is highly positively correlated with use of LPG, educated women use clean fuel for cooking from health and time perspective.[13] Use of solid biomass was significantly associated with wealth status of household. In our study, the odds to use unclean fuel was found more among poor income class respondents (AOR=3.09, CI=1.14-5.11, p<0.01) as compared to wealthy female respondents.[14] James et al (2020) analysed that socio economic status, education level, occupation and age were significantly associated with the use of unclean fuel. Odds of women who exposed to solid fuel showed a significant association with self -reported health problems.[15] While asking about non-adoption of LPG to tribal female participants, they reported major challenges in day-to-day life - lack of financial sources, high initial cost of LPG and monthly refill cost of cylinder. Furthermore, they pointed out lack of implementation of Pradhan Mantri Ujjwala Yojana in our remote hilly areas and didn't get timely subsidy through this program. One striking point was coming out in present study that few rich women participants used unclean biomass for the sake of tasty food and easy availability of animal waste and dry shrubs at home, without any consideration of serious health implications of solid fuel. Ranjan et al (2020) studied the pre and post implementation of PM Ujjwala yojana and found that program had failed to increases the consumption demand for clean fuel among rural people.[16,17] During survey, tribal females reported various health problems while preparing the food on traditional cookstove, it includes dermatitis, itchy skin or bruises, skin burns, throat itching, cough with phlegm, dry cough, running nose, nasal congestion, red and dry eyes, tearing of eyes, reduced eye vision, hypertension and cardio infections. These health problems were categorized into major headings for analysis. Being exposed to unclean biomass was significant associated with health problems among tribal women of Lahaul & Spiti- skin infection (AOR=4.62, CI=1.47-6.91, p<0.05), lower respiratory infections (AOR=2.85, CI=1.20 - 4.46, p<0.01), common eye infection (AOR=2.94, CI=1.05-6.08, p<0.05), chronic obstructive pulmonary disease (AOR=1.93, CI=1.55-4.05, p<0.05) and cardiovascular disease (AOR=4.24, CI=1.07-8.62, p<0.05). The findings of present study were consistent with past empirical studies conducted in rural areas [18,19,20]. Ravilla et al (20160 conducted a population-based study in north and south India and observed the association of solid biomass fuel with eye disease for women but not for men (AOR=1.20, CI=0.97-1.47, p<0.05) [21]. Sandra Ofori. et al studied in Nigeria and found that use of biomass fuel was significantly associated with high systolic blood pressure (OR = 1.67, CI=1.56–4.99, p<0.05) [22]. Weihua QU et al conducted study in China and found that use of solid fuels for cooking was significantly associated with diabetes, hypertension and chronic heart disease [23,24]. The outcomes of past studies were also consistent with our present study regarding association between respiratory disease and use of solid fuel for kitchen [25,26,27,28]. Liu et al conducted study in rural south China and showed that use of biomass fuel in house is highest risk factor for Chronic Obstructive Pulmonary Disease (COPD) [29]. Hence, ever expose to solid biomass fuel like firewood, charcoal, agriculture residue and animal waste for cooking creates more chances of health issues for women and children.

Conclusion and Implications of study

Indoor air pollution from burning of biomass fuel is a major risk factor for women and children's health, as they daily inhale harmful smoke. Various studies highlight the association between use of biomass and health problems. In conclusion, the current study is also highlighted the significant association between use of solid biomass fuel and health problems. As per the outcomes of the study, tribal females of Lahaul and Spiti highly dependent upon solid biomass without consideration about health implications due to various challenging obstacles of hilly terrain. The study revealed that more than 40% women ever exposed to solid fuel suffered from skin infections, eye infections and respiratory infections and nearly 18% tribal females suffered from lung and heart diseases. The study also highlighted the barriers toward non adoption of clean fuel and LPG reported by tribal females through face-to-face interview. Adoption of clean fuels and LPG in the tribal and remote areas of Lahaul and Spiti is restrained by a complex interaction of geographical, economic, and social barriers. The region's rugged terrain and remote settlement patterns create significant obstacles for regular LPG delivery, often requiring tribal households to walk long distances, sometimes up to half an hour or more, to collect cylinders from roadside drop-off points and pay additional handling fees. The initial costs associated with establishing an LPG connection—including government paperwork, a stove, and the purchase of one or more cylinders—can amount to several thousand rupees, imposing a heavy burden on low-income tribal households. Therefore, household in tribal and remote villages were heavily dependent upon solid biomass because of abundant access of free firewood which becomes a part of traditional cooking practices and act as a both cultural preference and practical substitute for LPG. Despite high economic growth and various government schemes for adoption of clean fuel, energy ladder is not realised in tribal and remote areas of India. On the basis of findings, improving LPG adoption in these regions requires addressing cost barriers, enhancing distribution infrastructure, fostering social acceptance and awareness about health benefits, and building sustained policy support that targets the tribal households of Lahaul and Spiti. Pradhan Mantri Ujjwala yojana should more strengthen in tribal and remote hilly areas so that poor and marginalised households can get subsidized LPG every month and refill their cylinders.

Limitations of study: The major limitation of current study is not full coverage of low populated villages of Lahaul and Spiti because the climate and terrain of Spiti valley is highly challenging for doing primary surveys. Moreover, children are not covered as a participant in this study. There is much scope to enhance research in these remote villages.

Declarations

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Ajaz Ahmad Ganaie (AAG): Questionnaire design and Writing review and editing
Jinny Sharma (JS): Conceptualisation, Methodology and Writing review and editing

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References

1. UNIDO, Sustainable energy for all, 19 may 2022. https://www.unido.org/news/sustainable-energy-all-unido-head-says-we-have-solutions-lets-act-now
2. International Institute for Population Sciences (IIPS) and ICF. 2021. National Family Health Survey (NFHS-5), India, 2019-21: Himachal Pradesh. Mumbai: IIPS. http://rchiips.org/nfhs/NFHS-5Reports/Himachal_Pradesh.pdf
3. https://web.umang.gov.in/landing/department/pradhan-mantri-ujjwala-yojna-pmuy.html
4. World Health Organization (2015). Air Quality and Health, Geneva, World Health Organization; 2015. https://www.who.int/docs/default-source/documents/publications/air-quality-and-health.pdf?sfvrsn=4f3710a8_1
5. World Health Organization. Fact Sheet household Air pollution,2022. Geneva, WHO. https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health
6. WHO. Household air pollution and health. 2014; Available from: http://www.who.int/mediacentre/factsheets/fs292/en/.
7. Mudway IS, Duggan ST, Venkataraman C, Habib G, Kelly FJ, Grigg J. Combustion of dried animal dung as biofuel results in the generation of highly redox active fine particulates. Part Fibre Toxicol. 2005 Oct 4;2:6. doi: 10.1186/1743-8977-2-6. PMID: 16202154; PMCID: PMC1262769.
8. International Energy Agency (2023), World Energy Outlook 2023, IEA, . Licence: Creative Commons Attribution CC BY-NC-SA 4.0.
9. Ranjan, R., & Bhadra, K. K. (2019). Impacts of Traditional Cooking Fuels on the Prevalence of Ailments in India. *Indian Journal of Human Development*, *13*(3), 294–307. https://doi.org/10.1177/0973703019900444
10. Kaur, M &Kaur, K., Dangerous cooking using unsafe fuels: A case study of Punjab, economic and Political weekly, 2021, 56(12). https://www.epw.in/journal/2021/12/commentary/dangerous-cooking-using-unsafe-fuels.html
11. Chattopadhyay, M., Arimura, T. H., Katayama, H., Sakudo, M., & Yokoo, H. F. (2021). Subjective probabilistic expectations, household air pollution, and health: Evidence from cooking fuel use patterns in West Bengal, India. *Resource and Energy Economics*, *66*, 101262.
12. Afridi, F., Debnath, S., Dinkelman, T., & Sareen, K. (2023). Time for clean energy? cleaner fuels and women's time in home production. *The World Bank Economic Review*, *37*(2), 283-304.
13. Gould, C. F., Urpelainen, J., & Sais, J. H. (2020). The role of education and attitudes in cooking fuel choice: Evidence from two states in India. *Energy for Sustainable Development*, *54*, 36-50.
14. Ali J, Khan W. Factors affecting access to clean cooking fuel among rural households in India during COVID-19 pandemic. Energy Sustain Dev. 2022 Apr;67:102-111. doi: 10.1016/j.esd.2022.01.006. Epub 2022 Feb 1. PMID: 35125780; PMCID: PMC8806018.
15. James BS, Shetty RS, Kamath A, Shetty A (2020) Household cooking fuel use and its health effects among rural women in southern India—A cross-sectional study. PLoS ONE 15(4): e0231757.https://doi.org/10.1371/journal.pone.0231757
16. Ranjan, R., & Singh, S. (2020). Household Cooking Fuel Patterns in Rural India: Pre- and Post-Pradhan Mantri Ujjwala Yojana. *Indian Journal of Human Development*, *14*(3), 518-526. https://doi.org/10.1177/0973703020975045
17. https://www.thehindu.com/news/national/ujjwala-scheme-90-lakh-beneficiaries-do-not-get-refills/article6540
18. Akomolafe JK. The burden and effects of cooking fuels usage on women in rural areas: A case study of Afao-Ekiti, Nigeria. Journal of Environmental Management and Tourism (JEMT). 2020;11(01 (41)):228-40.
19. Parikh J. Hardships and health impacts on women due to traditional cooking fuels: A case study of Himachal Pradesh, India. Energy Policy. 2011 Dec 1;39(12):7587-94.
20. Liu Z, Li J, Rommel J, Feng S. Health impacts of cooking fuel choice in rural China. Energy economics. 2020 Jun 1;89:104811.
21. Ravilla TD, Gupta S, Ravindran RD, Vashist P, Krishnan T, Maraini G, Chakravarthy U, Fletcher AE. Use of cooking fuels and cataract in a population-based study: the India Eye Disease Study. Environmental health perspectives. 2016 Dec;124(12):1857-62.
22. Ofori SN, Fobil JN, Odia OJ. Household biomass fuel use, blood pressure and carotid intima media thickness; a cross sectional study of rural dwelling women in Southern Nigeria. Environmental Pollution.2018. 242: 390–97. https://doi.org/10.1016/j.envpol.2018.06.102 PMID: 30005252 https://www.sciencedirect.com/science/article/abs/pii/S0269749118305062?via%3Dihub
23. Weihua QU, Zhijun YA, Guohua QU, Ikram M. Household solid fuel use and cardiovascular disease in rural areas in Shanxi, China. Iranian journal of public health. 2015 May;44(5):625. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4537619/
24. Qiu S, Chen X, Chen X, Luo G, Guo Y, Bian Z, Li L, Chen Z, Wu X, Ji JS. Solid fuel use, socioeconomic indicators and risk of cardiovascular diseases and all-cause mortality: a prospective cohort study in a rural area of Sichuan, China. International journal of epidemiology. 2022 Apr;51(2):501-13. https://academic.oup.com/ije/article/51/2/501/6372205
25. Po JY, FitzGerald JM, Carlsten C. Respiratory disease associated with solid biomass fuel exposure in rural women and children: systematic review and meta-analysis. Thorax. 2011 Mar 1;66(3):232-9. https://thorax.bmj.com/content/66/3/232.short
26. Torres-Duque C, Maldonado D, Pérez-Padilla R, Ezzati M, Viegi G. Biomass fuels and respiratory diseases: a review of the evidence. Proceedings of the American Thoracic Society. 2008 Jul 15;5(5):577-90. https://www.atsjournals.org/doi/full/10.1513/pats.200707-100RP
27. Prasad R, Abhijeet S, Garg R, Hosmane GB. Biomass fuel exposure and respiratory diseases in India. Bioscience trends. 2012 Oct 31;6(5):219-28. https://www.jstage.jst.go.jp/article/bst/6/5/6_2012.v6.5.219/_article/-char/ja/
28. Shrestha IL, Shrestha SL. Indoor air pollution from biomass fuels and respiratory health of the exposed population in Nepalese households. International journal of occupational and environmental health. 2005 Apr 1;11(2):150-60. https://www.tandfonline.com/doi/abs/10.1179/oeh.2005.11.2.150
29. Liu S, Zhou Y, Wang X, Wang D, Lu J, Zheng J, Zhong N, Ran P. Biomass fuels are the probable risk factor for chronic obstructive pulmonary disease in rural South China. Thorax. 2007 Oct 1;62(10):889-97. https://thorax.bmj.com/content/62/10/889.short
30. Faizan, M. A., & Thakur, R. (2019). Association between solid cooking fuels and respiratory disease across socio-demographic groups in India. *Journal of Health and Pollution*, *9*(23), 190911.
31. Hystad, P., Duong, M., Brauer, M., Larkin, A., Arku, R., Kurmi, O. P. [Prospective Urban and Rural Epidemiological (PURE) Study investigators]. (2019). Health effects of household solid fuel use: findings from 11 countries within the prospective urban and rural epidemiology study. *Environmental health perspectives*, *127*(5), 057003.
32. Yang, Y., Liu, Y., Peng, L., Zhang, S., Yuan, C., Li, W., ... & Ma, Y. (2022). Cooking or heating with solid fuels increased the all-cause mortality risk among mid-aged and elderly People in China. *Environmental Health*, *21*(1), 91.
33. Shen, S., Luo, M., Meng, X., Deng, Y., & Cheng, S. (2021). All-cause mortality risk associated with solid fuel use among Chinese elderly people: a national retrospective longitudinal study. *Frontiers in public health*, *9*, 741637.
34. Mohapatra, I., Das, S. C., & Samantaray, S. (2018). Health impact on women using solid cooking fuels in rural area of Cuttack district, Odisha. *Journal of family medicine and primary care*, *7*(1), 11-15.
35. Frostad, J. J., Nguyen, Q. P., Baumann, M. M., Blacker, B. F., Marczak, L. B., Deshpande, A.& Kapoor, N. (2022). Mapping development and health effects of cooking with solid fuels in low-income and middle-income countries, 2000–18: a geospatial modelling study. *The Lancet Global Health*, *10*(10), e1395-e1411.