Impact of Pradhan Mantri Ujjwala Yojana
Evidence from Jammu and Kashmir

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The impact of Pradhan Mantri Ujjwala Yojana on liquefied petroleum gas adoption and women's health in Jammu and Kashmir was studied through a survey of 820 households in Kulgam and Rajouri districts. Results showed that PMUY facilitated LPG adoption in 67.57% of households, increasing the LPG connection rate to 95.59%. However, 84.63% of households still rely on LPG and solid fuels, both due to affordability, access to cheaper firewood, and information and infrastructural challenges. While beneficiaries experienced health improvements, such as reduced respiratory ailments, these gains are constrained by continued solid fuel use. Complementary appliances, awareness campaigns, and improved infrastructure are critical to maximise PMUY's potential and promote exclusive clean fuel use.

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According to the International Energy Agency, approximately 681 million Indians still depend on biomass for cooking (Sharma and Dash 2022), posing serious health risks, particularly for women due to patriarchal norms and gendered household roles (Akter and Pratab 2022; Vyas et al 2021). A growing body of literature at the international level highlights the health and economic benefits of transitioning from traditional to modern cooking fuels (Martina et al 2020). The energy ladder hypothesis posits that the adoption of clean fuels progresses in phases, with income, starting with solid fuels, moving to transition fuels, and eventually to cleaner energy (Heltberg 2005). However, the consumption patterns observed in developing countries partly contradict the energy ladder hypothesis, particularly in rural areas, where higher incomes are associated with a combined use of solid fuels and clean technologies (called fuel stacking), rather than the exclusive use of clean fuels (Campbell et al 2003; Brouwer and Falcao 2004).

In India, Prime Minister Narendra Modi launched the Pradhan Mantri Ujjwala Yojana (PMUY) scheme in 2016, providing free liquefied petroleum gas (LPG) connections to women in low-income households. The scheme also offers subsidised gas refills. Over 10.3 crore gas connections have been distributed under the scheme (Jabir and Khan 2022). However, the existing literature presents an ambiguous picture regarding the role of PMUY in enhancing LPG adoption and women's health (Gupta et al 2020; Kar et al 2020; Swain and Mishra 2020).

The recent literature from several states of India has examined a host of factors associated with clean fuel adoption, ranging from household characteristics to forest proximity and infrastructural challenges (Sharma and Dash 2022; Kuo and Azam 2019; Sehjpal et al 2014; Pandey and Chaubal 2011). However, limited attention has been devoted to analysing cooking fuel consumption patterns and the role of the PMUY in Jammu and Kashmir (J&K). The distinct cultural, climatic, and socio-economic conditions in J&K, coupled with its mountainous terrain, make it a unique case for studying the role of energy subsidies in facilitating fuel-switching behaviour. Understanding how PMUY has influenced fuel choices and women's health in this region is crucial for targeted interventions and informed policymaking.

This paper addresses this gap by examining the cooking fuel consumption patterns and the role of the PMUY in J&K, using a primary survey covering 820 households in the Kulgam and

Rajouri districts, two disadvantaged regions in the union territory. To the best of our knowledge, this is the first paper on the PMUY and clean fuel adoption in J&K. We employ both quantitative and qualitative methods, such as structured questionnaires and in-depth interviews, and use propensity score matching (PSM) to test the statistical significance of our findings.

We find that the PMUY has succeeded in ensuring LPG connections reach the majority of poor households in rural J&K. Further, the PMUY beneficiary households report a higher LPG adoption and better health outcomes as compared to their non-PMUY counterparts. However, the results from the PSM reveal that the improvements brought about by the PMUY among the beneficiaries in terms of LPG adoption and health outcomes are limited. A key issue that undermines the full potential of the PMUY is fuel stacking, which persists among 84.63% of households in rural areas. Information gaps, affordability issues and lack of distribution centres in rural areas are significant barriers to clean energy adoption. We also highlight the role of modern appliances, such as rice cookers in clean fuel adoption. By developing novel insights regarding these critical aspects of fuel choice, our paper significantly contributes to the national discourse on the PMUY and clean fuel adoption.

Previous Literature

Research indicates that using solid fuels for cooking significantly raises environmental pollution levels (Chafe et al 2014), leading to increased cardiovascular diseases and cancer risks (WHO 2014; Lee et al 2014). Indoor and outdoor pollution exposure results in 3.5 million premature deaths annually worldwide (Susan et al 2020). Women and children bear the highest health burden due to gendered household roles (Paudel et al 2021). Previous studies show LPG stoves improve indoor air quality (Ekouevi and Tuntivate 2012) and deliver health benefits (Choudhuri and Desai 2020). These health improvements, coupled with time-saving benefits, can increase women's economic participation by freeing time for income-generating activities, thereby empowering women (Lin and Wei 2022).

The review of the literature on clean fuel adoption reveals that the continued use of solid fuels for cooking, especially in rural areas, is a complex problem driven by multiple factors. The price of clean fuels such as LPG remains a significant barrier, especially among poor households (Lewis and Pattanayak 2012). The energy ladder hypothesis suggests that fuel switching is largely determined by income and fuel costs (Heltberg 2005; Masera et al 2013). Beyond the income and affordability factors, the fuel choice is found to be influenced by household characteristics, such as family size, landownership, livestock, and educational attainment (Ekholm et al 2010). Some studies have associated the use of solid fuels with psychological factors and perceptions (Joon et al 2009), while others have highlighted infrastructural challenges, including limited access to markets and LPG distribution centres (Baquie and Urpelainen 2017).

Further, Bonan et al (2017) noted that demand-side policy interventions in the energy sector can succeed only if they are accompanied by strengthened supply chains. Aryal et al (2019) highlight the importance of developing off-farm employment opportunities, noting that the lack of paid work in rural areas lowers the opportunity cost of collecting solid fuels, which are often freely accessible in villages. Besides, Shrestha et al (2021) emphasise that disseminating information and encouraging women's participation in energy-related decisions can expedite the transition from polluting to cleaner fuels.

Theoretical Insights

Theoretical insights regarding fuel-switching behaviour initially emerged from the energy ladder hypothesis, which posits a three-stage transition from polluting to cleaner fuels based on rising income levels (Heltberg 2005). The transition is motivated by both energy efficiency and the higher socio-economic status associated with cleaner fuels (Kroon et al 2013). However, empirical evidence often reveals that households engage in fuel stacking—using multiple fuel types simultaneously—rather than making a complete shift (Yadav et al 2021; Cheng and Urpelainen 2014).

To develop further insights into fuel-switching behaviour, we argue that households face a complex cost-benefit analysis regarding their choice between solid fuels and cleaner fuels. Biomass-based traditional cooking has both private and social costs. The private costs of traditional cooking that are incurred by households include its negative health effects due to indoor pollution and time lost in wood preparation (Sharma and Dash 2022). The time burden of the firewood collection disproportionately affects women due to its gendered nature (Choudhuri and Desai 2020). However, due to limited paid work opportunities for women in rural areas, the time opportunity cost of firewood preparation often remains very low. On the other hand, the social costs of traditional cooking include environmental pollution, contributing to climate change, which affects the global economy. However, households do not take the social costs of traditional cooking into account, as it does not immediately affect them. Thus, a utility-maximising household will switch towards an exclusive clean cooking method only when the opportunity cost of time spent on firewood preparation, combined with the marginal pain caused by the negative health effects of indoor pollution, exceeds the price of cleaner fuels. Theoretical insights from Pattanayak et al (2018) further reveal that low-income households' marginal utility from environmental quality remains lower than the marginal utility derived from consuming goods and services, resulting in lower investments in health-improving technologies.

Households' switching behaviour is further hampered by information asymmetry. The lack of awareness and poor access to information can further influence households' assessment of the private costs of traditional cooking, resulting in suboptimal fuel choice (Dendup and Arimura 2019). In developing countries, such as India, imperfect information often leads to market failures, impacting the efficacy of energy policies (Jensen and Oster 2009). Addressing information asymmetry can play a critical role in influencing household fuel-switching

behaviour (Somanathan 2010). The theoretical insights discussed guide our data collection.

Data and Sampling Design

Our population comprises of households residing in the J&K region of India, covering two specific districts: Rajouri from Jammu Division and Kulgam from Kashmir Division. These districts, selected for their rural setting, infrastructural challenges, and proximity to forests, offer an ideal context for this research. Both districts are located along the Pir Panjal Range and are among the most remote and underdeveloped areas in J&K, with nearly 50% forest cover. Due to the mountainous terrain, agriculture is the primary source of income and livelihood in these districts.

The sampling frame primarily includes eligible below-poverty-line (BPL) households, both beneficiaries and non-beneficiaries of the PMUY scheme. To measure the impact accurately, we include a comparison group comprising relatively well-off households (above-poverty-line households) that are not entitled to subsidised LPG connections. The survey covered 820 households across 48 villages, with 24 villages in each district, and an equal sample of 410 households from Kulgam and Rajouri. All tehsils in both districts were included (12 tehsils in Kulgam, and seven in Rajouri). Villages were allocated proportionally to each tehsil based on the number of villages within each tehsil. Within each village, households were selected using systematic random sampling, with 17 households per village, except for one village in Kulgam (19 households) and two villages in Rajouri (18 households each), to reach the target of 410 households per district. The primary respondent for the quantitative data collection was the main female cook or co-cook in the household.

Data collection utilised a combination of quantitative and qualitative tools. Structured questionnaires were used to gather quantitative data, while in-depth interviews and focused group discussions were used to gain a deeper understanding of the nuances of the problem. To control for confounding factors, we divide our sample into various strata considering their socio-economic backgrounds. Further, our empirical design relies on PSM analysis.

Propensity Score Matching

We perform the PSM analysis to empirically measure the impact of the PMUY on the eligible beneficiary households and test its statistical significance. First, we define the treatment in terms of eligible households that have registered for subsidised LPG under the PMUY. The control group includes households that are eligible but have not registered under the scheme. Then we apply the propensity scoring matching to identify the comparable households from the control group for the treated households based on observable characteristics at the individual, household, and village levels. The matching is achieved by condensing the multidimensional covariates into a probability that the household has registered for subsidised LPG under the PMUY. After this matching, any observed difference in the outcome variables of our interest between the treated and control groups can be attributed to the true effect of the PMUY.

This method ensures that the treated and non-treated households are similar in terms of observable characteristics. The probability scores can be estimated using a Probit model. We used 17 covariates and also included village dummies in the model for the probability estimation. The list of covariates can be seen in Table 6 (p 58).

The estimated probabilities or propensity scores are then used for matching similar households. For matching, we first use one-to-one nearest neighbour matching and employ a calliper of 0.01, ensuring that the PMUY beneficiary and non-PMUY beneficiary households are matched only if their propensity scores do not differ by more than 0.01. The narrow margin minimises the likelihood of poor-quality matches between the groups. Then we check the robustness of the findings using an alternative matching method: Kernel matching with Epanechnikov Kernel (bandwidth of 0.01). To check whether the matching approach has successfully identified a comparable control group for PMUY beneficiary households, we examine the standardised percentage bias. It measures the difference in covariate means between treated and control groups as a percentage of the standard deviation of the covariate, after balancing.

Descriptive Analysis

Before discussing the empirical findings from the PSM analysis, it is useful to perform a descriptive analysis. A descriptive analysis enables us to take a detailed look at the energy consumption patterns across different sample strata and offers useful insights into various dimensions of the problem, including the effectiveness of the PMUY. However, to check the statistical significance of the impact size, we rely on results from the PSM analysis, as it accounts for confounding factors and presents a clear picture regarding the level of achievements made under the PMUY.

Consumption Patterns, Awareness, and Appliances

We first review the overall fuel consumption patterns, status of LPG connections, and awareness levels among households in the sampled districts. Table 1 (p 56) shows that 85.07% of households have an official LPG connection, while 10.53% possess an unofficial connection, and 4.41% have no LPG connection at all, resulting in an overall LPG connection rate of 95.59%. A notable 67.57% of households acquired LPG connections during the PMUY implementation period, indicating significant PMUY coverage, though the scheme's primary goal remains to promote regular use of LPG over traditional fuels.

Despite the high coverage, Table 1 also shows that 91.71% of households still possess traditional stoves (*daans*), often used for various purposes. Furthermore, 90.85% of households continue to use solid fuels for cooking, and 84.63% use a combination of solid fuels and LPG, highlighting a fuel stacking issue. The average LPG consumption over the last six months among sampled households was 3.56 cylinders, indicating moderate adoption. However, firewood use for cooking during this period was notably high, averaging 226 kilograms (kg). These

patterns show that households rely heavily on solid fuels despite having LPG access. This combination of traditional and modern fuels complicates the transition and necessitates a deeper understanding of its underlying causes.

Table 1 also reports household awareness levels regarding the benefits of cleaner fuels versus the disadvantages of solid fuels. We find that 47.44% of households are unaware of the health benefits associated with cleaner cooking. Additionally, 64.15% of households lack a television, and one-third (32.68%) of women responsible for cooking do not own a mobile phone, signifying the need for information campaigns in these far-flung areas. A study from Kerala suggests that information campaigns significantly promote clean fuel adoption in rural areas (Krishnapriya 2022).

PMUY and Clean Fuel Adoption

To assess the impact of PMUY on clean fuel adoption using simple descriptive analysis, we conducted a group-wise cross-sectional analysis. We first examined the data for the Kulgam district. The descriptive statistics are presented in Table 2. The analysis focuses on three key variables: LPG consumption (in cylinders used), firewood consumption (in kg), and the percentage of households using both LPG and solid fuels (indicating fuel stacking) over the past six months.

Table 2 shows that average LPG consumption among general LPG consumer households is 3.57 cylinders, nearly identical to the PMUY beneficiaries, who average 3.54 cylinders, with only a minor difference. In contrast, non-PMUY LPG households report an average of 3.21 cylinders, noticeably lower than that of PMUY beneficiaries, suggesting that the PMUY has contributed to increased LPG adoption. A similar trend is observed in firewood consumption, where non-PMUY LPG households consume the most firewood (245 kg), while the PMUY households consume considerably less (214 kg). However, fuel stacking remains high among PMUY households at 93%, compared to 89% among general LPG users.

Interestingly, Table 2 also reveals that LPG consumption among PMUY beneficiaries is notably higher for those who own rice cookers (3.59 cylinders) or solar panels (3.77 cylinders), underscoring the role of complementary appliances in encouraging energy transition. Awareness and beliefs play important roles as well: PMUY beneficiaries are aware of the health benefits of clean cooking and consume more LPG (3.73 cylinders). During in-depth interviews, some households, particularly those adhering to traditional beliefs, expressed preferences for food cooked on traditional stoves due to perceived taste differences. The PMUY households that do not report taste differences and consume higher amounts of LPG (4.27 cylinders) indicate that these perceptions may hinder the shift to cleaner cooking.

On the supply side, LPG adoption also appears linked to subsidy receipt practices. Households, where the LPG refill subsidy is directed to the bank account of the primary cook (often female), report significantly higher LPG consumption (3.88 cylinders). This arrangement, where the female cook receives the subsidy directly, promotes financial inclusion and may incentivise a stronger shift towards LPG.

Similar patterns are observed in firewood consumption, where

Table 1: Cooking Methods, Energy Consumption Patterns, and Awareness in J&K

S No		Variable	Values (%)
1	Status of LPG connections	Households with an official LPG connection	85.07
2		Households with an unofficial LPG connection	10.53
3		Households with no LPG connection	4.41
4		Households that procured LPG under PMUY (after May 2016, the PMUY implementation period)	67.57
5	Cooking methods and consumption patterns	Households with traditional stoves (Daan)	91.71
6		Households with LPG	95.59
7		Households using solid fuels for cooking	90.85
8		Households using LPG for cooking	93.54
9		Households using both solid fuels and LPG for cooking (fuel stacking)	84.63
10		Adoption rate of LPG (No of cylinders)	3.56
11		Average firewood consumption for cooking (in kgs)	226
12	Lack of awareness	Households not aware of the health benefits of using clean fuel (LPG)	47.44
13		Households not aware of the negative health effects of using burning solid fuels	46.76
14		Households not owning a television set	64.15
15		Households where a female member is responsible for cooking do not possess a mobile phone	32.68
16	Complementary appliances	Households with a rice cooker	53.17
17		Households using solar energy	11.46

Source: Authors' calculations.

Table 2: Impact of PMUY and Other Factors on Clean Fuel Adoption in Kulgam, Kashmir

Household Category	Variables (Mean Values)		
	LPG Consumption (Number of Cylinders Consumed)	Firewood Consumption (kg)	Households Using LPG and Solid Fuels (Fuel Stacking) (%)
General LPG consumer households	3.57	206	89
PMUY beneficiary households	3.54	214	93
Eligible but non-PMUY LPG consumer households	3.21	245	93
Eligible and PMUY beneficiary households with awareness about the health benefits of LPG-based cooking	3.73	216	93
Eligible and PMUY beneficiary households with no family member feeling the taste difference between traditional and LPG-based cooked food	4.27	220	100
Eligible and PMUY beneficiary households, when the subsidy is credited to the main cook's bank account	3.88	184	90
Eligible and PMUY beneficiary households with a rice cooker	3.59	185	92
Eligible and PMUY beneficiary households with a pressure cooker	3.47	204	93
Eligible and PMUY beneficiary households with education (secondary or above)	3.50	185	92
Eligible and PMUY beneficiary households with a gas agency in the village	3.49	210	88
Eligible and PMUY beneficiary households with multiple cylinders	3.46	192	93
Eligible and PMUY beneficiary with solar panels	3.77	218	90

Source: Authors' calculations.

the PMUY beneficiary households with access to modern appliances, such as rice cookers and pressure cookers, report lower solid fuel use (185 kg and 204 kg, respectively). Moreover, households with multiple cylinders or access to a local gas agency report reduced firewood consumption (192 kg and 210 kg, respectively). However, Table 2 also suggests that the PMUY's effectiveness in promoting exclusive LPG use remains limited, as fuel stacking persists among most households.

The group-wise fuel consumption patterns for Rajouri district, a region with significant disadvantages due to its mountainous terrain, are presented in Table 3. We see that LPG consumption among PMUY beneficiary households is 3.14 cylinders, higher than the 2.8 cylinders reported by non-PMUY households. This adoption rate further increases among households with modern appliances like rice cookers (4.5 cylinders) and pressure cookers (3.36 cylinders), as well as for those with access to sources of information, such as television ownership and mobile phones (4.16 and 3.15 cylinders, respectively). Likewise, households with some awareness of the negative effects of using solid fuels report higher LPG consumption (3.2 cylinders).

Table 3: Impact of PMUY on Clean Fuel Adoption among the Poorest (AAY Households) in Rajouri District

	LPG Consumption (Number of Cylinders Consumed)	Firewood Consumption (in kg)	Percentage of Households Consuming Both LPG and Solid Fuels (Fuel Stacking)
Non-PMUY beneficiaries	2.8	317	50
PMUY beneficiaries	3.14	212	88
PMUY beneficiary with a rice cooker	4.5	173	75
PMUY beneficiary with a pressure cooker	3.36	215	91
PMUY beneficiary with a gas agency in the village	3.75	201	75
PMUY beneficiary households, when the subsidy is credited to the main cook's bank account	3.5	195	100
PMUY beneficiary with multiple cylinders	3.16	230	100
PMUY beneficiary with television ownership	4.16	195	83
PMUY beneficiary with a mobile phone in the household	3.15	206	88
PMUY beneficiary households with awareness about the negative health effects of solid fuel-based cooking	3.28	260	71

Source: Authors' calculations.

From the supply side, our data shows that households with a gas agency in the village have higher LPG consumption (3.75 cylinders). Additionally, if the subsidy is credited directly to the cook's account, LPG consumption rises from 3.14 to 3.5 cylinders over a six-month period. These trends also hold when assessing firewood consumption. Table 3 reveals that firewood use among PMUY beneficiary households is only 212 kg, compared to 317 kg for non-PMUY households. Firewood consumption drops further to 173 kg for households with rice cookers, and to 201 kg among PMUY households with a local gas agency. Similarly, households with television sets or mobile phone ownership reduce firewood use to 195 kg and 206 kg, respectively. Households where the main cook directly receives the subsidy report even lower firewood consumption (201 kg). However, similar to Kulgam district, fuel stacking remains prevalent among PMUY beneficiaries in Rajouri, indicating a need for additional targeted government interventions. Notably, the PMUY's positive effects in Rajouri are especially evident among the poorest households, such as Antyodaya Anna Yojana (AAY) cardholders.

What Explains the Fuel Stacking Problem in J&K?

Overall, the descriptive statistics suggest that the PMUY has indeed encouraged clean fuel adoption in the disadvantaged districts of J&K and reduced solid fuel use, particularly in households with better access to information, modern appliances, and infrastructure. However, the improvement in the clean fuel adoption among PMUY households as compared to non-PMUY households seems limited, and only a statistical test can tell us whether the difference in LPG adoption rate between these two groups of households is significant (statistical test results are presented later in this paper).

Using in-depth interviews, we attempted to delve deeper to unravel the factors that explain the fuel stacking practice among these households. The qualitative interviews reveal two main explanations. First, many of the households, especially in Kulgam district, have apple orchards. The regular pruning required for maintaining the health and productivity of apple trees generates substantial wood, which can be used for cooking. Orchard owners often share some of their wood with their neighbours and relatives. Hence, most of the households (86.82%) have free access to a regular supply of firewood. Further, due to limited paid work opportunities for females in rural areas, the time opportunity cost of wood preparation for cooking is often very low. Therefore, by spending some of their available time on wood preparation, they reduce LPG consumption, thereby reducing some financial burden for their households. Thus, even if a household is financially well-off, the probability of using solid fuels and traditional stoves remains high.

Further, due to limited electricity in J&K, especially in six months of extreme winter, rural households often rely on fire pots for heating, for which they need a significant amount of charcoal. The sample households reported an average of eight hours of intermittent power cuts from 6 am to 11:59 pm. As a result, their average firewood requirement for charcoal preparation stands at 89 kg per month. The charcoal can be generated as a by-product of solid fuel-based cooking, and hence, the burning of the firewood in traditional stoves serves the dual purpose of cooking and charcoal generation. This results in fuel stacking, hampering exclusive LPG adoption.

Second, many households cited affordability as a factor hampering LPG adoption. The price of LPG refill (14 kg) during the survey period remained around ₹1,000, "which is too high for us to afford," a female respondent said.

The additional factors that compound the problem are the lack of awareness or information and access to modern appliances, among households. A large section of the population (46.76%) is unaware of the negative health effects of burning solid fuels. This unawareness is linked to a lack of

education and access to media. The illiteracy rate among female cooks is 47.56%. Further, 64.15% of the households do not have a television set, while 32.68% of female cooks have no access to a mobile phone. Modern appliances, such as rice cookers, play a complementary role in LPG adoption. However, only 53.17% of the households possess a rice cooker and only 11.46% use solar energy.

Thus, the existing fuel stacking practices in the unique settings of J&K are necessitated by the region's cold climatic conditions and are influenced by a complex set of factors. These factors range from the free or cheaper supply of wood from orchards to economic and infrastructural backwardness combined with limited access to information and the non-availability of complementary appliances. The lack of affordability of LPG remains another key factor.

PMUY and Women's Respiratory Health Outcomes

We examine the impact of PMUY on women's respiratory health outcomes in Rajouri and Kulgam, specifically focusing on incidences of coughing, headaches, and chest infections or breathing difficulties reported over the past month. The results, presented in Tables 4 and 5 for Kulgam and Rajouri, indicate a decrease in these conditions among PMUY beneficiaries compared to non-beneficiaries, although the decline is modest.

In Kulgam, the incidence of coughing among BPL PMUY beneficiaries fell from 24% (for non-beneficiaries) to 21%, and dropped further to 20% among those with a rice cooker or pressure cooker. Among the AAY ration card holders who are PMUY beneficiaries, coughing incidence was 10%, lower than 13% among non-beneficiaries. The AAY households with pressure cookers showed only 8% incidence of coughing, while households with respondents holding at least secondary education reported a further reduction to 6%. Similar patterns were observed for headaches, with BPL and AAY households reporting a decrease of 1 and 2 percentage points, respectively, among PMUY beneficiaries. Chest infection incidences dropped by 2 percentage points for both BPL and AAY PMUY households.

In Rajouri, health improvements were notably consistent among AAY households, the region's poorest. Table 5 shows that PMUY beneficiaries with AAY ration cards reported a 12% incidence of coughing, slightly lower than the 13% seen among non-beneficiaries. For breathing difficulties, PMUY beneficiaries experienced a 6 percentage point drop compared to non-beneficiaries (from 13% to 7%), and headaches decreased by 1 percentage point among these households.

Overall, our analysis shows a reduction in respiratory issues among PMUY beneficiaries across both districts, although the effect size remains small. Two main factors could explain the limited health impact of PMUY. First, fuel stacking is widespread, with 84.63% of households using both traditional stoves and LPG. This dilutes the health benefits of LPG adoption. Health improvements require exclusive clean fuel adoption, which has not been achieved in the rural areas of J&K. Second, most of the households use traditional stoves outdoors, and for those with indoor stoves (which account for a small percentage), most have chimneys to vent smoke, reducing indoor air pollution to some extent.

Empirical Results from PSM Analysis

Before we come to the average treatment effect, let us take a look at the balance test results, as shown in Table 6. The percentage bias for each covariate remains low, and most of the p-values are statistically insignificant, suggesting that the matching is successful. The overall median bias is only 4.9 and it has a high p-value of 0.34, suggesting that the difference in mean values of the covariates between PMUY beneficiary and non-PMUY beneficiary households after matching is insignificant, suggesting that the matching is successful.

The final results of the PSM are presented in Table 7 (p 59). We present both the unadjusted difference (unmatched) in the

Table 4: Health Effects of PMUY and Other Factors in Kulgam District (%)

	Incidence of Coughing		Headache		Chest Infection	
	BPL Households	AAY Households	BPL Households	AAY Households	BPL Households	AAY Households
Non-PMUY beneficiaries	24	13	24	13	8	8
PMUY beneficiaries	21	10	23	15	6	6
PMUY beneficiary with a rice cooker	20	8	20	13	5	5
PMUY beneficiary with secondary or above education	20	6	18	25	4	6

Source: Authors' calculations.

Table 5: Health Effects of PMUY among the Poorest (AAY Households) in Rajouri District (%)

	Incidence of Coughing	Breathing Difficulties	Headache
Non-PMUY beneficiaries	13	13	13
PMUY beneficiaries	12	6	12
PMUY beneficiary with a rice cooker	0	0	0

Source: Authors' calculations.

Table 6: Balance Quality after Matching, Using Nearest Neighbour Method (Calliper/BW: 0.01)

Variable	Mean		t-test		
	Treated	Control	Percentage Bias	t	p>t
Frequency of transport facility	0.64	0.7	−11.50	−1.27	0.21
Age of the female cook	40.15	40.51	−2.90	−0.32	0.75
Level of education of the female cook	1.47	1.58	−7.10	−0.76	0.45
Availability of a bank account	0.95	0.95	−3.20	−0.42	0.68
Availability of a mobile phone	0.68	0.64	8	0.87	0.38
Age of the primary income earner	44.01	42.93	9.19	1.02	0.31
Family size	5.62	5.48	7	0.74	0.46
Television ownership	0.35	0.32	7.9	0.87	0.38
Availability of a motor vehicle/bicycle	0.27	0.26	1	0.10	0.92
Availability of a rice cooker	0.52	0.59	−14.30	−1.57	0.12
Power cuts (frequency in hours)	8.22	8.13	6.1	0.70	0.49
Availability of a solar panel	0.1	0.08	7	0.82	0.42
Availability of a biomass stove	0.93	0.97	−13.80	−1.93	0.06
Cultivable land size	79.61	78.98	.6	0.06	0.95
Livestock population	1.89	1.89	−0.10	−0.01	0.99
Female labour force participation rate	0.13	0.16	−6.20	−0.65	0.52
Awareness about the demerits of traditional cooking	0.64	0.62	4.4	0.470	0.64

Median bias = 4.9; P-value = 0.34
Source: Authors' calculations.

outcome variables and the average treatment effect on the treated (ATT). The unadjusted difference measures the raw difference between the treated and control groups before matching without accounting for differences in covariates, while the ATT measures the adjusted difference after matching. In Table 7, we can see that in terms of LPG adoption rate, the ATT is positive 0.3. However, it has a low t-statistic value of 1.02, which does not exceed the critical value at a 5% level of significance. Similarly, in the case of firewood consumption, we find that ATT for the PMUY beneficiary households is –36.31, but it also has a low t-stat value of –0.94, making the impact size statistically insignificant. Finally, in terms of the incidence of respiratory sickness among the women who are responsible for cooking, the ATT is only 0.07, indicating that there is no significant difference in women's respiratory health outcomes between treated and control groups. The negligible difference in the health outcomes is also supported by a low t-stat value of 1.17. We perform a robustness check using Kernel matching with Epanechnikov Kernel and a bandwidth of 0.01. The results based on Kernel matching are presented in Table 7. However, the magnitude and statistical significance of the ATT from this method remain consistent, which increases our confidence in the reliability of our findings.

Table 7: Average Treatment Effects on Fuel Choice and Respiratory Health Outcomes for PMUY Beneficiary Households

Variable	Sample	Treated	Controls	Difference	SE	T-stat
Nearest neighbour matching/calliper (0.01)						
LPG adoption rate	Unmatched	3.38	3.73	–0.35	0.20	–1.76
	ATT	3.35	3.06	0.29	0.29	1.02
Firewood consumption	Unmatched	232.96	259.23	–26.27	20.53	–1.28
	ATT	232.83	269.15	–36.31	38.81	–0.94
Incidence of respiratory sickness	Unmatched	0.29	0.23	0.06	0.04	1.59
	ATT	0.29	0.22	0.07	0.06	1.17
Kernel matching/Epanechnikov kernel (BW: 0.01)						
LPG adoption rate	Unmatched	3.38	3.72	–0.35	0.20	–1.76
	ATT	3.35	3.27	0.08	0.26	0.29
Firewood consumption	Unmatched	232.96	259.23	–26.27	20.54	–1.28
	ATT	232.83	271.00	–38.17	31.39	–1.22
Incidence of respiratory sickness	Unmatched	0.29	0.23	0.06	0.04	1.59
	ATT	0.29	0.24	0.05	0.05	0.92

Source: Authors' calculations.

Conclusions

The first notable finding of the study is that 95.59% of the households in the rural areas of J&K now have LPG connections, including 85.07% official and 10.53% unofficial connections. This figure is noteworthy, as 67.57% of official connections were procured under the PMUY scheme after its implementation in May 2016. Only a small fraction of households (4.41%) in rural areas particularly in hilly regions like Rajouri (in Jammu) do not have access to LPG.

However, despite this substantial increase in LPG availability, traditional cooking methods remain pervasive. Approximately, 91.71% of the households still maintain traditional stoves, and a staggering 84.63% of the households engage in fuel stacking, using both solid fuels and LPG. The PMUY beneficiary households do observe a higher LPG adoption rate and have slightly better health outcomes than their eligible non-PMUY counterparts. However, the results from the PSM reveal that the difference in the outcome variables between PMUY and non-PMUY households is not statistically significant. Further, the overall LPG adoption rate among PMUY beneficiaries is still significantly lower than that of general category (non-eligible) LPG consumers, calling for increased policy attention.

The survey reveals that 84.63% of households indulge in fuel stacking, stifling the full potential of PMUY. A complex set of factors explains the fuel stacking problem in rural areas. The key factors include the high price of LPG refills, lack of awareness and information, access to free firewood, and low time opportunity cost of wood preparation (due to the lack of paid work opportunities in rural areas), limited access to complementary appliances and LPG distribution centres, among others. The findings of our paper call for increased policy attention in ensuring accessibility of LPG among poor rural households and a regular supply of electricity. Further, providing greater tax concessions on complementary appliances, such as electric rice cookers and awareness programmes in far-flung areas, could help in realising the full potential of PMUY.

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