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Do all the empowered women promote smokeless kitchens? Investigating rural India

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ABSTRACT

Cooking with solid fuels is still prevalent in rural India. Decades long clean cooking policies paid little attention to its primary users, women. Using a binomial logit model we prove that household's use of clean cooking fuel is associated with woman's financial independence, her bargaining power and improved opportunity cost of her time. More importantly, the study adds to the existing literature by highlighting the significance of favorable socio-cultural circumstances for women empowerment to realize into smokeless kitchens. Woman's awareness of ill effects of burning solid fuels; gender relations; and woman's access to market, influence the degree to which women empowerment manifests into adopting clean cooking fuel. By using two rounds of National Family Health Surveys conducted in 2015–16 and 2019–21, the study is first of its kind to examine the pre and post scenarios of one of India's largest clean cooking fuel scheme- Pradhan Mantry Ujwal Yojna. The analysis shows that woman's agency and less/more favorable contexts in which it is exercised, continues to be the key to households adopting clean cooking fuel in rural India even though the policy intervention eased the economic burden of owning the necessary cooking technologies.

1. Introduction

High dependence on solid fuels (SFs) for cooking continues to plague rural India. According to National Family Health Survey-5(IIPS & ICF, 2020), only 43 percent of the rural households use clean fuel (Electricity, LPG/natural gas, biogas). Indoor air pollution, according to a government of India report (Indian Council of Medical Research et al., 2017), was responsible for 5 percent of the total disease burden in 2016. And, according to WHO (WHO, 2018), 11 percent of India's premature mortality burden due to non-communicable diseases is due to chronic respiratory diseases, which is primarily caused by indoor pollution. Study by (M. B. Jakovljevic and Milovanovic, 2015), elucidates the escalating burden of non-communicable diseases in the global south and its significant impact on the economies' increasing health expenditure.

In the last two decades, due to a rise in the household income and subsidy on LPG cylinders, cooking fuel scenario in rural India witnessed a shift towards cleaner sources.[1] However, this shift was gradual and notable changes occurred only among households from higher wealth deciles (six and above) (See.Fig. 1). In 2016, targeting the poor and socially disadvantaged, India launched a clean cooking fuel programme-Pradhan Mantry Ujwal Yojna-that achieved near universal LPG connection. Under this scheme, the State bore the upfront lumpsum cost of LPG connection and stove. From Fig. 1 it is evident that post PMUY, solid fuel usage among the poor (1–3rd/4th wealth decile households) decreased. The results, however, are far from intended i.e., smokeless kitchens for all. Ideally, a universal clean cooking programme should result in clean fuel usage by all as depicted by the bottom most dotted line in Fig. 1. High recurring costs of refilling cylinder, difficulty in accessing urban centric LPG distribution system, easy access to SFs are a few reasons that has driven the rural households back to SFs, after initial success of the programme (Swain and Mishra, 2020).

India's efforts to promote smokeless kitchens focuses on the economic aspect of the physical infrastructure. This still leaves more than half of the rural households dependent on SFs. Limited success of these polices begs to look past the economic factors. Clean cooking processes has a direct bearing on the time, health, and labor borne by the woman and it effects the rest of the household by extension. Therefore, adoption and consistent use of clean cooking technologies, should ideally rest on and driven by women. Gendered nature of energy access, benefits, and interlinkages between women's agency and choice of clean cooking fuel is a growing body of literature. Studies examined woman's status in the household and its association to the household's choice of cooking fuel.

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[1] Just 6 percent in 1998 99 (International Institute for Population Sciences (IIPS) & ORC Macro, 2000).

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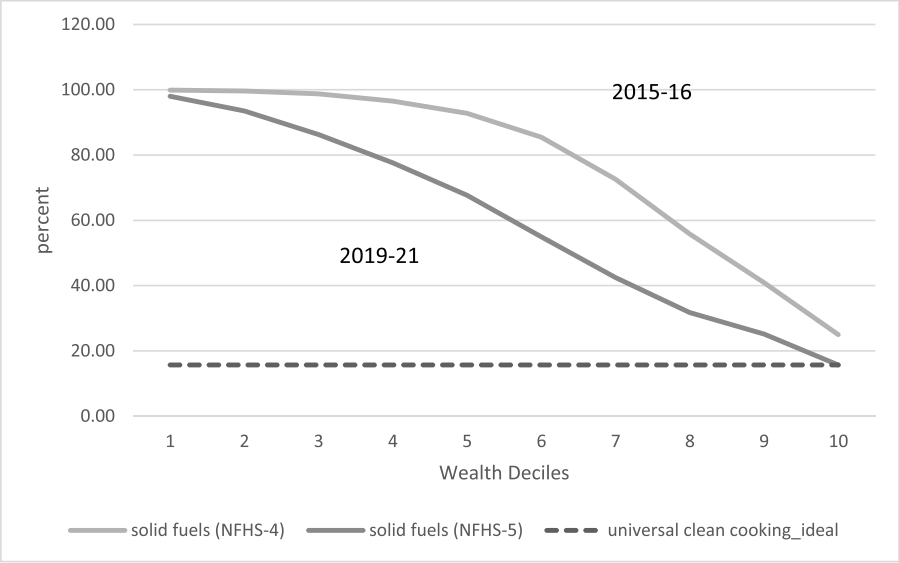


Fig. 1. Solid Fuel Users Across Economic Group. Source: Calculated using NFHS-4 (2014–15) and NFHS-5 (2019–21).

Recent study by Choudhuri and Desai (Choudhuri and Desai, 2020a) provides a comprehensive review of the literature in this regard. Notwithstanding a number of studies advocating gender component in clean fuel policies, its absence in India's decades long clean cooking fuel policies is a partial indicator of a disengagement between theory and policy. Present study is an attempt to bridge this gap by asking the following questions.

i. Do all the factors that improve women's agency increase the household's chances of using clean cooking fuel?
ii. Does improvement in the woman's status trump all economic and socio-cultural hindrances to use clean cooking fuel?

The paper is organized as the following. Literature review is presented in section II followed by an analytical frame in section III. Data and the methodology are discussed in section IV. Sections V and VI present results and robustness check of the model respectively. Last section concludes the paper with a discussion.

2. Literature review

" More research is needed to understand the factors-both outside and within the household-that influence women's decision-making power in relation to the adoption of modern energy services" (Pachauri and Rao, 2013). This section does not dwell on justifying the importance of understanding the gendered nature of energy access nor reiterate the importance of clean energy services on women's welfare. Instead, we lay ground to investigate the association between factors that improve woman's agency and the household's choice of clean cooking fuel, and factors both within and outside the households that dictate this association.

2.1. Women empowerment and choice of cooking fuel

Woman's intra household bargaining power and the household's choice of cooking fuel accounts for a significant body of literature in the field of gender and energy. Intra-household negotiations do not usually take place between equals (Clancy, et al., 2012). Doss presents a range of economical and socio-cultural indicators and proxies to examine woman's decision making and bargaining power and their correlation with developmental outcomes (Doss, 2013). Following are a few studies that found positive association between owning clean cooking technologies/using clean cooking fuel and woman's bargaining power in case of India- (Gould and Urpelainen, 2020; Choudhuri and Desai, 2020a; Mohapatra and Simon, 2017; Kishore and Spears, 2014) (Das, undated).

Woman's engagement in employment is another factor that had been examined in relation to the household's cooking fuel choice. Woman's participation in labor force is perceived as the opportunity cost of her labor/time. That is women have or do not have a next best alternative to the labor/time she spends on arduous cooking process. According to Nathan low-opportunity cost of women's labor will inhibit the adoption of labor-saving equipment, while a high opportunity cost will promote it (Nathan et al., 2018). Similar observations are made by Wickramasinghe, in the case of Sri Lanka(Wickramasinghe, 2011). Also, engagement in paid employment activities boosts the woman's bargaining power as she actively contributes to the household's income.

2.2. Gains in Women's agency: Are there limits?

Social norms lie outside the immediate control (or agency) of individuals and play a role in determining 'the possible' when it comes to the choices women may decide to make and to enact (Galiè and Farnworth, 2019). In some situations, for women, it is rational to avoid negotiation (Croson and Gneezy, 2009).

Women are more sensitive to social cues in determining appropriate behavior than men (Croson and Gneezy, 2009; Dániel Horn et al., 2022). Therefore, hardship involved in cooking with *freely* available SFs, especially when the household resources are limited or accessing clean fuel comes with a social cost (like travelling which is judged unfavorably), might just be another household responsibility women are expected to bear. Studies have proved that in case of limited resources and greater prioritization of the good of the household, women prefer to divert the funds away from clean cooking technologies/fuel (Fingleton-Smith, 2018; Mobarak et al., 2012). Women, in general, are more altruistic than men therefore allocate and spend resources that accrue overall welfare to the household (Dasgupta and Mani, 2013; Quisumbing and Maluccio, 2000). If women do not realize that clean cooking fuel benefits not only her but the entire household, especially the health of the children, it is highly unlikely she would bargain for or spend on it.

The "stickiest" aspect (of the social norms) is the way patterns of gender inequality are reproduced over time and often passed on over generations (World Bank, 2012). Navigating these norms to formulate preferences, exercise their agency while avoiding social costs is

challenging for women (Hannah Riley Bowles et al., 2007). Women bargaining and/or spending resources on (seemingly) self-serving goods and services involves a high risk of *backlash* from the husband/partner or head of the household. Also, social norms determine the context in which the markets and institutions operate. The nature, degree of rigidity/persistence of these norms and women's response to it determines the success of laws, schemes, or developmental programmes. Therefore, even though complementary or sequential policies are in place to iron out the gender inequalities and bring forth their combined impact on women's welfare, their success is highly dependent on the degree of stickiness of the social norms.

3. Analytical framework

We examine association between three women empowerment indicators-women's decision on household spending, her financial independence and improved opportunity cost of her time- and the household's choice of cooking fuel.

3.1. Decision making power

Women with decision making authority on household spending, are likely to bargain for cooking fuel that involves less drudgery, more leisure and lessens health risks. Literature argues that women with autonomy make decisions that are beneficial to the household in general and children in particular like better diet, clothes, attending school etc (Kabeer, 1999). Considering the improvement clean fuel brings over SFs, women with a say on household spending are likely to bargain for clean fuels (Choudhuri and Desai, 2020a; Das, undated; Mohapatra and Simon, 2017; Zhang et al., 2022).

3.2. Financial independence

Financially independent woman would invest on goods and services that accrue welfare to the household in general. Therefore, they play a key role in choosing clean cooking fuel (Parikh, 2011). Access to ready cash and freedom to use it allows them to articulate their energy needs better and have more authority to take decisions (Pachauri and Rao, 2013), therefore ensuring its consistent use.

3.3. Decision making power and financial independence: in context

Men and women have unequal capacity to exercise their agency (World Bank, 2012). These capacities determine the degree to which women's agency manifests into a desirable development outcome. Clancy et al. proposes that household outcomes, especially in a gender equitable way, are a result of an interplay of factors at *individual, household, and institution* spheres (Clancy, et al., 2012). Loosely adopting this framework, study examines woman's empowerment in these three domains. Capacities a woman has in each of these domains are termed as *context* in this paper, i.e., a woman operates in less/more favorable contexts. These contexts, we propose, defines the association between woman's empowerment and the household's choice of cooking fuel.

At the **individual** context woman's knowledge (or lack of) of the ill effects of burning SFs on the health will influence her to bargain for or spend on clean cooking fuel. We hypothesise that woman's decision-making authority and financial independence will have higher chances of translating into using cleaner fuel if she is aware of health damage caused by burning SFs.

At the **household** context, gender relations between the husband and the wife affects her autonomy in the economic sphere, especially her spending decisions. Trust and communication between spouses have a telling impact on the decisions made within the household (Doss, 2013). In this case, if the husband distrusts the wife or restricts her autonomy, we hypothesise that it is less likely she will exercise her financial independence and decision making power to spend on clean cooking fuel.

Finally, in the context of the **society**, rules and regulations by which women operate is highly likely to determine the aspects on and the degree to which she will exercise her autonomy and financial independence. For example, restrictions on woman's movement to marketplace and beyond affects her access to goods and services like LPG. We hypothesise that, women are less likely to bargain for and/or spend on goods/services whose procurement comes with a cost of defying socially approved conventions.

3.4. Improvement in opportunity cost of women's time

Woman spending time away from home on productive activities, increases the household's chances of opting clean cooking fuel. However, 'improvement' in the opportunity cost of women's time is contingent on two components-time spent on employment activities and mode of payment for her work.

3.4.1. Time

Yearlong engagement in employment activities sends strong signals about woman' s time use away from home and her unavailability to take up time intensive household chores. In such a case, woman's labour is unavailable for collecting and managing SFs, thus the household is likely to shift to less labour-intensive cooking technologies like LPG. However, if the woman is engaged in employment activities occasionally or seasonally, i.e., when her labour and time for the major part of the year is 'free' and 'available', households are unlikely to make a permanent shift towards time-saving cooking technologies. We hypothesise that households where women work year-long has higher chances to use clean fuel as opposed to household were women work occasionally or seasonally.

3.4.2. Pay

Monetary emoluments for woman's work are a visible indicator of her contribution to the household economy. Therefore, women engaged in employment activities that rewards in cash is highly likely to be relieved from the drudgery of collecting and using SFs for cooking. On the other hand, if women are paid in kind, or not at all, it is unlikely that household would shift towards less labour-intensive cooking processes. We hypothesise that households where women are engaged in yearlong paid work have better odds to use clean cooking fuel than those households where women do not earn in cash.

4. Data and methodology

4.1. Data

The data source for this study is National Family Health Survey (NFHS). NFHS is a large sample national survey that collects information on household's social (religion and caste) and economic characteristics (a wealth score is calculated based on ownership of few major assets and appliances) including amenities like water, electricity, cooking fuel, and sanitation. Information about members' age, education attainment, access to media, employment is also gathered. More importantly, for this study, survey provides clues for studying women empowerment through gender relations, spousal violence, employment and earning, ownership of assets, intra household bargaining power among the others.

In this study, we conduct analysis at two points of time 2015 16 and 2019-21 by using two rounds of NFHS data- NFHS-4 (conducted between January 2015 to December 2016) and NFHS-5 (conducted between June 2019 to April 2021) (IIPS & ICF, 2020; Indian Institute of Population Sciences & ICF, 2017). These two time periods mark the completion of the first five years of implementation of PMUY. Examining the gendered dynamics in the household's cooking fuel choice pre and post key policy intervention is one of the major contributions of the study and first of its kind. This exercise is crucial in establishing the relevance of gender dynamics in the household's choice

of *using* cooking fuel even after the policy intervention eased *owning* it.

Since SF usage is disproportionately high among the rural households, present study solely focuses on them. Further, keeping in view the objectives and analytical framework of the study, the model considers the sample of households comprising of eligible women[2] who are presently married and selected to be interviewed for domestic violence module. Only women from these sample were asked relevant questions like "who makes a decision of large household purchases?" "Who decides how to spend husband's earnings" "are you allowed to go to the market?" and other "control" questions. The useful[3] sample size of NFHS-4 and NFHS-5 is 45033 and 46340 respectively.

4.2. Variable definitions

4.2.1. Dependent variable

The dependent variable is a binary variable indicating the household's choice of main source of cooking fuel. Variable takes value 1 if clean, 0 otherwise.

4.2.2. Independent variables

i. Women's **participation in household spending** is measured as a combination of her involvement in large household purchases and her say on spending of husband's earnings. Unlike one-time large household purchases like appliances, vehicle, furniture etc, spending on clean fuel like LPG or electricity for cooking affects the monthly budget of the household. Woman's participation in occasional purchases reveal little about her say on spending household resources on day-to-day needs. Therefore, the woman of the household is considered to participate in household spending only if she *also* has a say in her husband's earnings. This is a binary variable that takes value 1 if both the conditions are satisfied and 0 otherwise.

ii. A woman is **financially independent** if she has money that either she alone can decide how to spend or has bank or savings account that she can use. This too is a binary variable that takes value 0 or 1. Use of services like clean cooking fuel like LPG involves cash transactions and therefore woman's access to ready cash, rather than ownership of assets, is likely to determine her autonomy and readiness to choose clean cooking fuel.

In order to fully understand the association between woman's unrestricted ability to spend on recurring expenditure such as cooking fuel, we eliminate the possible impact of her general 'financial strengths' on fuel choice. Therefore, the model controls for woman's financial strengths i.e., her ownership of assets and/or her earning in cash.

iii. **Contexts**: Woman's access to media is a proxy of her **awareness.** Especially newspaper and radio could be sources of information on the range of health problems caused if exposed to indoor air pollution. This is a dichotomous variable that takes value 1 if the respondent accesses newspaper or radio at least once a week and 0 otherwise. **Husband's distrust or control** of wife is a cumulative score calculated based on the number of times the respondent answered 'yes' to six questions[4] depicting husband's distrust or control he exerts on the wife. The value of the score ranges from 0 to 6. If the woman of the household is free to travel to the market and outside the village alone then the variable **mobility** takes the value 1 and 0 if not.

As we examine empowerment indicators in these three contexts, we use interactive variables i.e., interaction of the *indicator* and *context*.

iv. **Women's opportunity cost of time** Here we examine the two components of employment *-time* and *mode of payment.* Weather she is engaged in employment throughout the year/not, and engaged in employment throughout the year for cash/not. For both these components, the variable is a dichotomous variable that takes value 1 or 0.

Value of woman's time spent on employment could be partially determined by her employer. Working for the family (agriculture/business) could be perceived as her time well spent than working for somebody else. Alternatively, working for the family is one of her many household responsibilities, therefore working for somebody else signals limits to her time. Either way, the employer, partially determines the value household places on woman's time on employment activities. Therefore, the model controls for the employer while examining the association between opportunity cost of woman's time and the household's fuel choice.

Definitions of all the variables and summary statistics are presented in Tables 1 and 2 respectively.

Table 1
Variable definitions.

Sl. No	Variable	Definition
1	**Clean cooking fuel**	1 if electricity/LPG/biogas and 0 if coal/lignite/charcoal/wood/agricultural crop/dung/kerosene and others
2	**Financial Independence**	1 if respondent has access to cash which she alone can decide how to spend or has bank or savings account, 0 otherwise
3	**Spending Decision**	1 if woman part takes decision on household purchases and decision on husbands' earnings, 0 otherwise
4	**Improved Opportunity Cost**	Work all year = 1 if the woman work throughout the year and 0 if works seasonally/occasionally Salaried = 1 if the woman working throughout the year is paid in cash and 0 if not.
5	**Education**	Education = 1 if the respondent's highest education level is at least primary education and 0 otherwise
6	**Religion (Ref: Hindu)**	Christian, Muslim and Others
7	**Household size**	Number of the household members
8	**Age of the woman**	In years
9	**Caste (Ref: SC)**	ST, OBC and Others
10	**Wealth group**	The entire sample is divided into five deciles based on wealth index factor score*. Poor:1st +2nd deciles, Middle Income:3rd +4th deciles and Rich: 5th deciles
11	**Awareness**	Awareness = 1 if women access newspaper or radio at least once a week, 0 otherwise
12	**Husband's distrust/ control**	Score ranging from 0 to 6 depending on the number of times the respondent answered 'yes' to six control/trust questions.
13	**Mobility**	Mobility = 1 if women can go to market and outside the village alone and 0 otherwise
14	**Employer**	Employer = 1 if respondent works for the family and 0 if works for somebody else or self-employed.

Note: *: Wealth index score is a composite measure that is calculated using easy-to-collect data on a household's ownership of selected assets.

4.3. Methodology

We conduct binary logit model. Let U^* be the maximum attainable

[2] i.e., between age group of 15–49.

[3] after dropping the households with missing values on the dependent variable i.e., primary source of cooking.

[4] husband/partner jealous if respondent talks with other men" "accuses respondent of unfaithfulness" "does not permit respondent to meet female friends", "limits contact with family and friends", "insists on knowing where respondent is", "doesn't trust respondent with money".

Table 2
Summary Statistics in percentage.

	Wealth Group1		Wealth Group 2		Wealth Group 3		All	
Variables	A	B	A	B	A	B	A	B
Clean cooking fuel	1.31	11.16	23.47	50.79	67.06	79.57	23.28	40.69
Financial Independent	54	83.36	65	88.35	76	89.77	63	86.64
Decision maker	79	71.36	81	70.16	83	70.08	81	70.62
Works*	41	40.75	34	39	25	28.67	35	37.63
Works all year*	17	18.80	18	21.80	16	17.92	17	19.82
Salaried*	13	14.53	13	17.99	13	14.94	13	15.99
Educated	40	51	69	72	87	88	61	67
Religion: Christian	6.34	9.07	8.36	7.39	6.78	4.32	7.24	7.45
Hindu	79.36	75.92	74.88	77.07	73.24	75.17	76.35	76.23
Muslim	11.13	11.35	11.84	10.80	10.44	10.27	11.28	10.91
Others	3.16	3.66	4.92	4.74	9.54	10.24	5.14	5.41
Avg. age of the woman	32.11	33.12	32.57	33.71	33.65	34.17	32.60	33.56
Avg. size of the household	5	5	5	5	5	5	5	5
Caste: SC	22.25	21.73	20.52	21.03	14.01	16.70	19.92	20.43
ST	32.18	36.31	19.53	18.57	10.00	7.35	22.75	23.33
OBC	36.20	32.77	40.22	43.47	41.99	43.57	38.95	39.26
Others	9.38	8.46	19.73	16.38	33.99	32.06	18.38	16.41
Awareness	5.18	3.51	5.11	8.86	5.23	20.23	5.16	8.99
Average control score**	1.41	1.24	1.02	1.03	0.82	0.83	1.13	1.08
Free to travel	38.70	45.24	43.82	45.69	49.14	47.56	42.83	45.88
Assets	49.00	44.90	44.66	41.79	40.20	38.62	45.51	42.40
Sample Size	18032	18536	18036	18536	8965	9268	45033	46340

Note: A: 2015–16 and B:2019–21. *: As a percentage of entire sample **: As a percentage of woman who reported to work.
**: Score ranges from 0 to 6.

utility the household gets by adopting one of the two choices of energy-clean and unclean cooking fuel. U_{ij}^{*} as the realised utility that a household i gets by choosing particular choice j. Stochastic utility of the i*th* household faced with j(=1 or 0) choices is

$$U_{ij}^{*} = \boldsymbol{X}_{ij}^{/}\boldsymbol{\beta} + e_{ij} \quad (1)$$

$\boldsymbol{X}$ represents the vector of empowerment indicators of the woman of the given household i and other explanatory variables, which are household-specific, individual specific and region-specific. These include, economic status of the household, social factors like religion and caste, household size i.e., number of members in the household; characteristics of woman like her age, her education etc. If the household makes choice j = 1 or j = 0, then we assume that U_{ij}^{*} is the maximum among the J pay-offs. Hence, the statistical model is driven by the probability that choice j = 1 is made, such that Pi1 = Prob(U*i1>U*i0). The model aims is to predict the probability Pi1.We assume that the logit L is a linear explanation

$$L_i = \boldsymbol{X}_{ij}^{/}\boldsymbol{\beta} \quad (2)$$

Equation (2) is expanded according to the empowerment indicator or indicator context interactive variable, depending on the model.

Across and within countries, gender gaps widen at lower incomes, and, in the poorest economies, gender gaps are larger (World Bank, 2012). Therefore, we examine the association between women's agency and the choice of fuel across broad economic categories. We carry out analysis for three wealth groups-poor, middle income and rich under two time periods-pre and post PMUY.

5. Results

At the outset woman empowerment has a positive association with

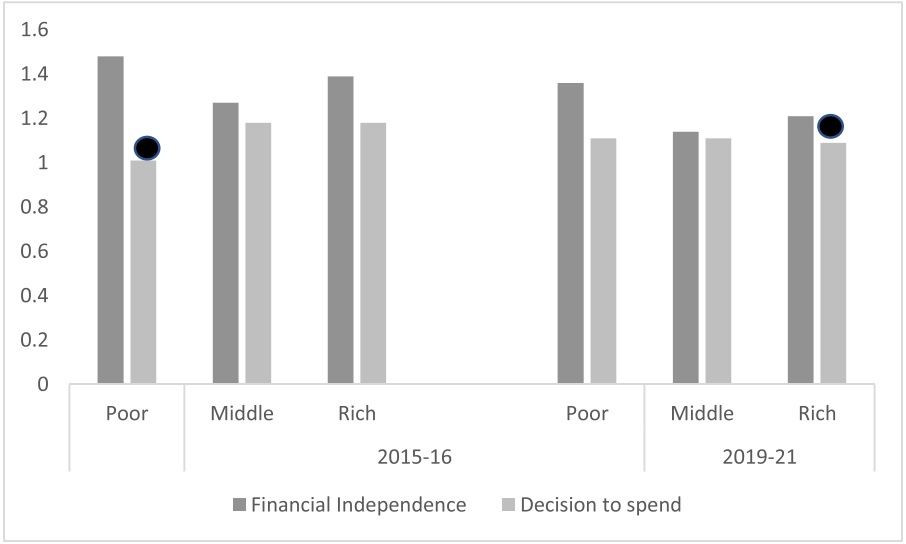
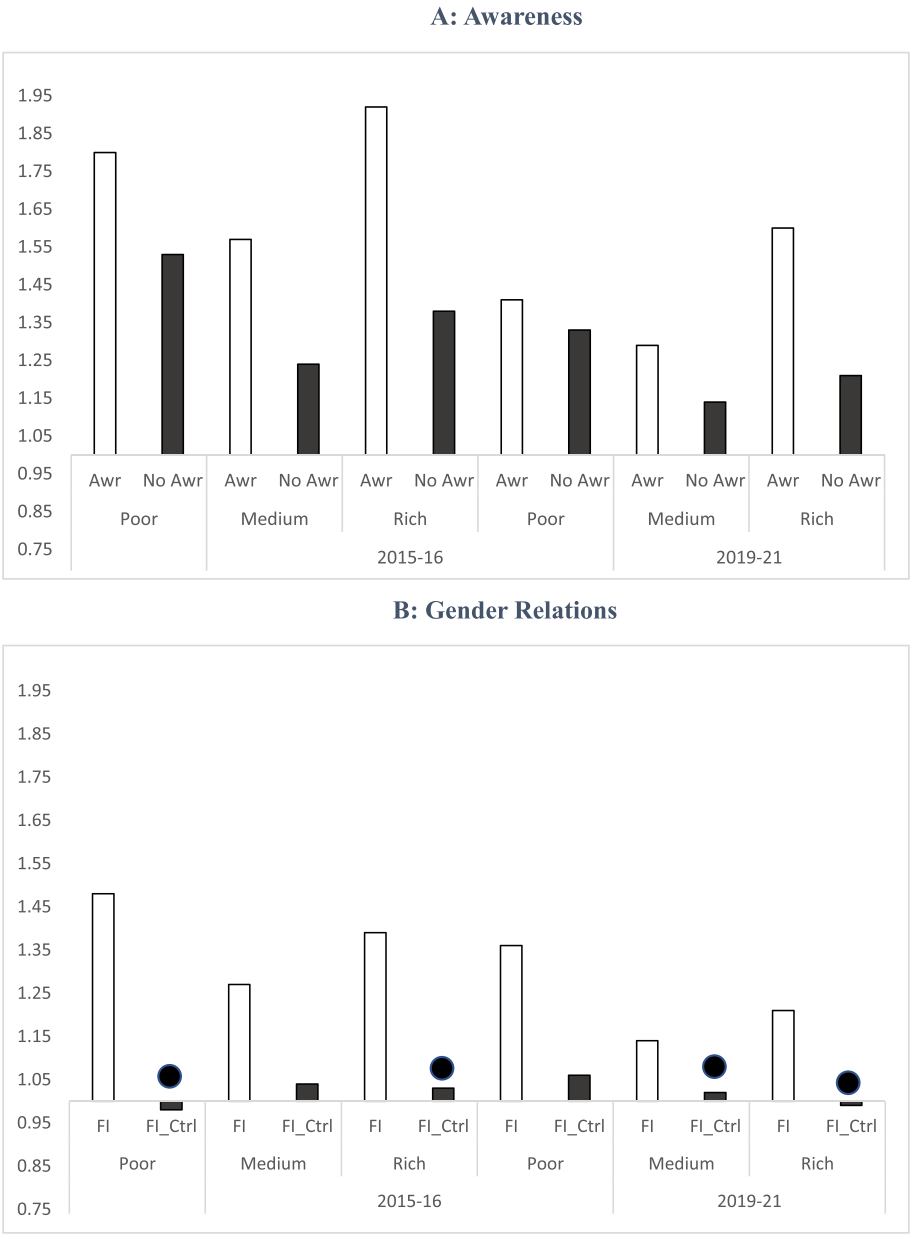


Fig. 2. Financial Independence and bargaining power - household's odds to use clean cooking fuel (2015 16 and 2019–21).



the household's usage of clean cooking fuel. However, all the empowerment indicators do not have a positive and statistically significant association with the household's use of clean cooking fuel across the wealth groups. Also, awareness, social norms and economic constraints dictate the degree to which women empowerment manifests into smokeless kitchens. Figs. 2–5 present women empowerment indicators and the households' odds to use clean fuel. See Appendix-A tables A1-A6 for the likelihood estimates of the models.

Woman's financial independence notably improves the household's odds to use clean cooking fuel. Of all, among the poor households the odds for clean fuel improves significantly, by 48 percent and 36 percent during pre and post policy periods respectively, if the woman has access to ready cash. As expected, the contexts in which financially independent women exercise their agency determine the odds for clean fuel. If the woman is aware of the ill effects of using SFs, the household's odds of using clean fuel improves by many points than woman having access to cash but unaware of the hazards. With every one unit increase in the spousal distrust score, the chances of the woman promoting the use of clean cooking fuel falls. These observations are true for all the wealth groups pre and post PMUY. Woman's freedom to move and use of clean fuel has positive association among the middle and rich households. Among the poor, however, only after necessary physical infrastructure is made available through PMUY, woman's mobility has statistically significant association with the household's use of clean cooking fuel.

Women's bargaining power significantly improves the chances for clean fuel. The results concur with the observations made by (Choudhuri & Desai, 2020; Das, undated). However, a closer look reveals that, while this is true for middle and rich households for both the time periods, for the poor, however, it was evident only in the second period (Fig. 2). PMUY enabled ownership of LPG connection and stove among the poor, probably, was the threshold that was needed to witness the implication of woman's bargaining power on the household's use of clean fuel. The positive association between woman's bargaining power and fuel usage in the second period reiterates the fact that *using* LPG is still dependent

Fig. 3. Women's Financial Independence and Household's choice of cooking fuel in three contexts (Odds Ratio). A: Awareness. B: Gender Relations. C: Movement. Note (for fig.2-5): The dots on the bar indicate that the results are statistically insignificant.

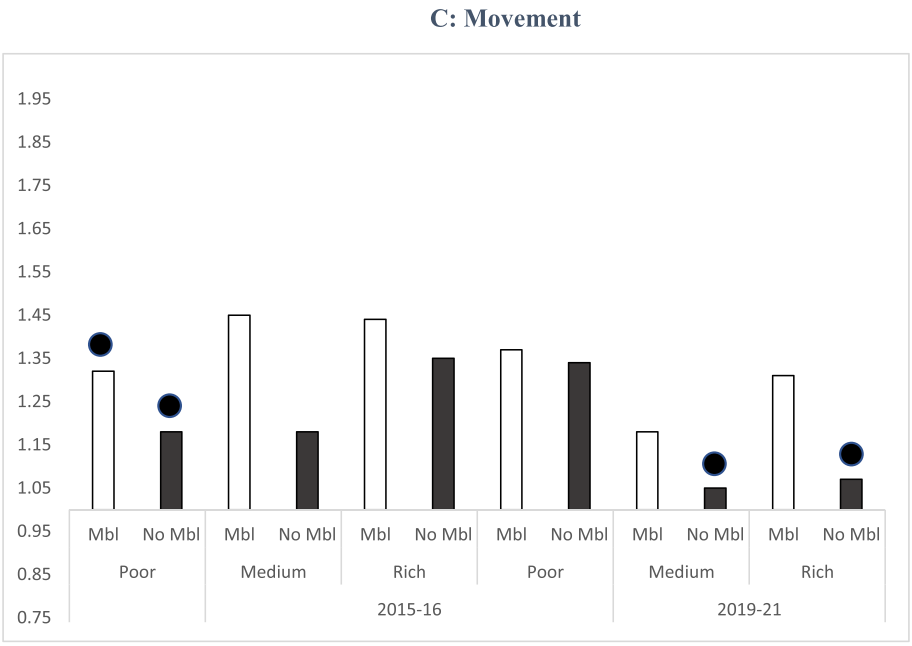


Fig. 3. (*continued*).

on woman's agency even though the State enabled *access* to it. Again, the context in which women exercise their bargaining power determines the households' chances of using clean fuel. Woman's awareness improves the chances to bargain for clean fuel by many folds. As the husband's distrust score increases, even though the wife reports to participate in household spending, the odds for clean cooking fuel diminishes. Restrictions on travelling, reduces her odds to successfully bargain for clean fuel.

Improvement in the opportunity cost of woman's time increases the household's odds of using clean fuel. Among the middle and the rich households where woman work throughout the year, as opposed to working occasionally, the chances of using clean fuel improves. Among the poor, contradicting the hypothesises, working throughout the year does not promote the use of less-labour intensive cooking technologies. Paid work, in contrast to working for kind or no pay, improves the chances for clean fuel, significantly so among the poor households. This is true for all the wealth groups in the first period. However, in the second, woman earning in cash does not promote usage of clean fuel among the poor. A combination of significant hike in the LPG refill and minimal rise in wages could be the reason. Between 2017 and 2020 the subsidised LPG refill cost increased by 65% (mypetrolprice, 2022), the average daily wage among rural women increased only by 28%[5] (Labour Bureau of India, 2022). Therefore, it is possible that women's time away from home for relatively meagre earnings is unlikely to encourage a poor household to use clean fuel as a main source of cooking.

6. Robustness check

6.1. Women empowerment and other consumption goods

To be sure that the above observed results confirm the association between women empowerment and fuel choice and does not reflect unobserved differences between the households, we conducted a placebo test similar to that of Choudhuri and Desai (Choudhuri and Desai, 2020a). We replaced cooking fuel in equation (1) (section 4.3) with two sets of household goods. One set is of common interest to the household-TV or fridge and the other is vehicle (two-wheeler and or car/truck) generally used by men (rather than women) in rural India. We do not expect, women's access to ready cash or her bargaining power to be associated with the household owning household appliances or vehicle. Placebo test confirms the hypothesis (results presented in table A7, appendix) and confirms strong interlinkages between woman's agency and goods/services that has a bearing on her labour, time, and health.

6.2. Disproving endogeneity: employment and fuel choices

The relation between woman's employment and choice of cooking fuel could be both ways. A woman engaged in employment activities throughout the year, might encourage the household to use less labour-intensive cooking processes. Similarly, less labour-intensive cooking process might free up time for woman to pursue employment throughout the year. To address this possible endogeneity, an exercise is conducted to prove that the average cooking time does not (statistically) differ for the women engaged in occasionally/seasonally or year-long employment, thereby negating the possible impact of (less/more) cooking time on the employment options. Using Time Use Survey, 2019 (MoSPI, 2020), a *t*-test was conducted to confirm that the average time spent on meal preparing and related activities by two groups of rural employed women, as mentioned above. The results, as presented in Appendix-A table A8. indicate that less/more time spent cooking does not necessarily influence woman's employment choices thus negating the simultaneity issue.

7. Conclusion and discussion

The study shows that women empowerment is one of the effective enablers of smokeless kitchens in rural India. Household where woman has bargaining power, access to finances, and engaged in employment activities, has better odds of adopting clean cooking fuel. These observations are valid for pre and post PMUY. Further, the study proves that

[5] More than 70% of rural women from poor wealth decile are engaged in agricultural activities. The average daily wage rate for rural women engaged in agricultural labor increased from Rs.190 to Rs.248 between 2015 16 and 2020-21.

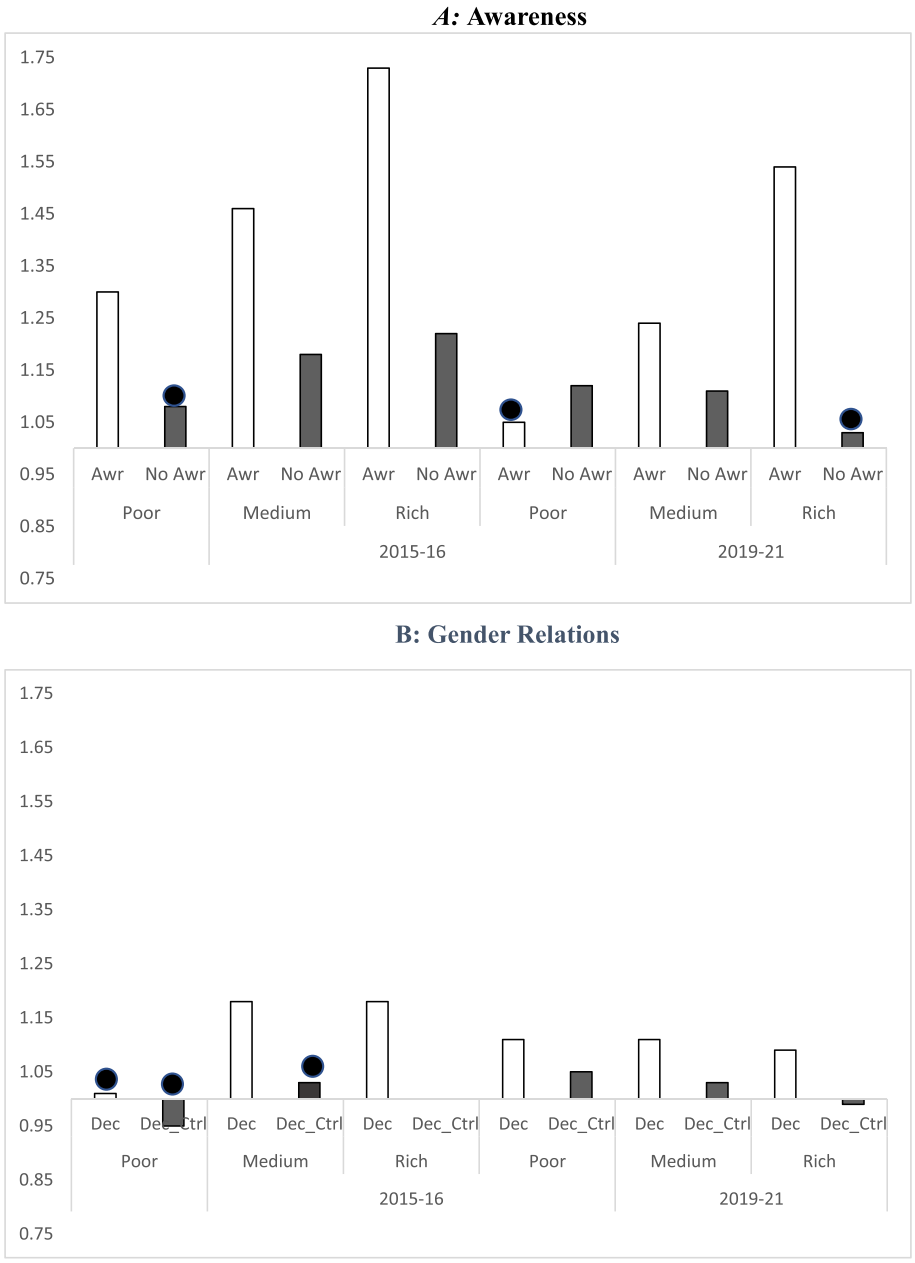


Fig. 4. Women's Decision to Spend and Household's choice of cooking fuel in three contexts (Odds Ratio). *A:* Awareness. B: Gender Relations. C: Movement.

woman's knowledge of the ill effects of solid fuel usage, gender relations and her access to market are crucial for women empowerment to translate into smokeless kitchens.

The contribution of the present paper to the gender energy discourse is twofold. First, the association between women empowerment and fuel choice is not uniform across the wealth groups. Second, the relation between women empowerment and clean fuel choice depends on favorable/unfavourable socio-cultural contexts.

Studies propose that as the opportunity cost of woman's time improves, odds for clean fuel increases (Choudhuri and Desai, 2020b; Nathan et al., 2018). In our study, however, we find that this relationship is complex. For example, we found that, while the opportunity cost of a woman's time improves the chances for clean cooking among the medium-income class and rich, it does not release woman of a poor household from the drudgery of cooking with solid fuels. In other words, in a poor household woman's time away from home and her earnings cannot override the cost component of LPG refill cost.

Kabeer's influential study on State's policies and women empowerment states that "These various interventions (for women empowerment) are simply different entry points into this larger project, each with the potential for social transformation, but each contingent on context, commitment and capacity if this potential is to be realised" (Kabeer, 1999). The present study finds this to be true in the case of clean cooking fuel schemes, especially the nature of inter-household gender relations and woman's ability to access market. Realising this at a policy level is key as these contexts are sticky, habitual, and persistent in rural India.

Notwithstanding the State policies that made ownership of the technologies possible, we find that adoption of clean fuel is dependent on the women of the household. These results are in accordance with the recent most study by (Zhang et al., 2022) which concluded that "despite the availability of clean cooking fuels (facilitated by PMUY), women with different levels of empowerment may hold diverging views that make them hesitant to adopt LPG".

The study, therefore, offers two interlinked policy suggestions. First,

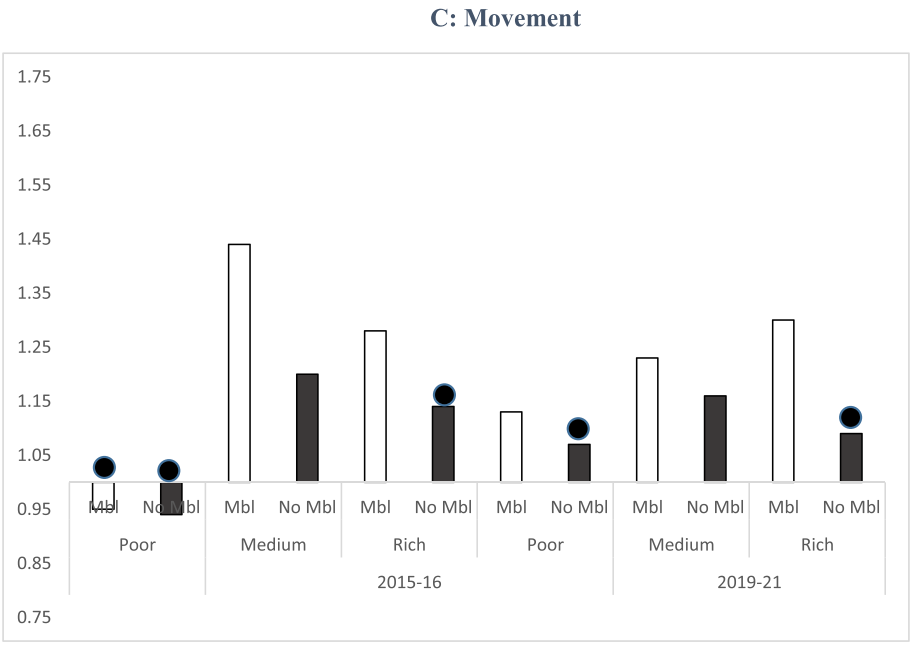


Fig. 4. (*continued*).

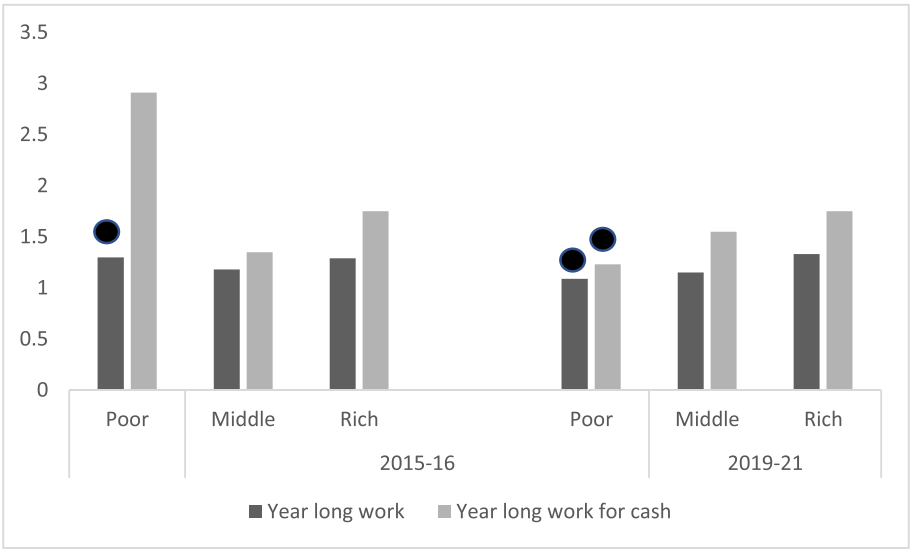


Fig. 5. Women's Improved Opportunity Cost of Time and Household's choice of cooking fuel: Odds Ratio.

the State ought to acknowledge woman's role and incorporate gender components in promoting necessary conditions/channels that lead households to adopt and consistently use clean cooking fuel. Secondly, policy attempts to improve women's agency and thereby enhance the odds for clean cooking fuel must account for the unrelenting socio-economic and cultural structures that determine this association. A network system of necessary demand and supply conditions that could override such structures should become an extended component to the current PMUY scheme. This includes spreading knowledge and awareness of the health risks caused due to indoor pollution and benefits of smokeless cooking; promoting existing clean cooking policies and availability of related subsidies. (Mohapatra and Simon, 2017) in their study on modern cook stoves proposes the use of public media as a means to empower women with the knowledge about the health effects of traditional cook stoves. Easing the financial and physical burden of accessing LPG refills is key for consistent usage of LPG. Small women groups (akin to self-help groups) at village/panchayat level could be one way to build a network system. This could be a platform to encourage their members to put away micro sums to spend on refilling LPG cylinder. These groups could foster a supportive social setting where bargaining for, spending on, accessing and consistently using clean cooking process bypasses socio, economic and cultural rigidities.

Clean cooking fuel needs to be considered as a component of public health system. It should be prioritized, promoted and financed under major health programmes- TB eradication, women's pre and post-natal health programmes, infant and child health. Health financing need not necessarily be the flows within jurisdiction of health systems. Harnessing the support of other sectors is smarter way to stimulate actions to attain health goals (M. Jakovljevic et al., 2019a). State's efforts to ensure consistent use of clean cooking fuel is an investment to create healthy, productive human capital that will yield long term benefits. Appropriate investment in health system needs to be driven by the awareness that population health has a significant impact on socio-economic productivity(M. Jakovljevic et al., 2019b).

CRediT authorship contribution statement

Sravanthi Choragudi: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data used in the study is an open source data. The references to the data is in the text of the paper.

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