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"Sustainable Cooking Practices in India: An Analysis of Women's Shift towards Eco-Friendly Fuels"

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Abstract:

Women's time savings for fuel collection, preparation, and cooking are less well-known than clean cooking fuel's health and environmental benefits. By cooking in both rural and urban areas, LPG can lessen the disproportionate amount of unpaid labour that falls on women and provide clean energy for everyone (Akter 2021). The International Institute of Population Sciences and ORC Macro's Third, Fourth, and Fifth National Family Health Surveys, conducted in 2005–06, 2015–16, and 2019–20, provide demographic and health survey data from 29 Indian states used in this analysis. We used the female NFHS 3, 4, and 5 data. Take note of the variable "kind of fuel household uses primarily for cooking." There are non-green fuels, biogas, LPG, NPG, and electricity.Our objective is for Indian women to transition from NFHS 3 (2005–06) to NFHS 4 (2015–16) and from NFHS 4 to NFHS 5 using environmentally friendly fuel. The chisquare test and Markov Chains model are applied. Indian women are switching to environmentally friendly fuel, according to Chi-square. Next, we created the matrix of transitional probability. Of the women in NFHS 3 (2005–06) and 4 (2015–16), 54% converted to environmentally friendly fuel. Of all women, 46% still use non-green fuel.However, the percentage of Indian women who switched from non-eco-friendly to eco-friendly gasoline (33%) fell from NFHS 4 to NFHS 5. Additionally, 17% of the females are moving from environmentally friendly to non-eco-friendly fuel. It's the Indian government's PMUY's fault.

Keywords: Eco-friendly fuel, NFHS,PMUY, Sustainable Development Goals.

Introduction

The availability of clean and inexpensive energy is of utmost importance for the promotion of health, well-being, and socio-economic progress. Conventional cooking fuels, including firewood, crop residues, and cow dung, as well as conventional cook stoves, are known to release various pollutants into the atmosphere, such as carbon dioxide (CO2), respirable particles, carbon monoxide (CO), nitrogen oxides (NO; N2O), and sulphur (S), thereby contributing to air pollution (Bruce et al., 2015; Cameron et al., 2016; Kandpal et al., 1995; Smith and Sagar, 2014). The detrimental impact of air pollution on the environment has been well documented (Singh et al., 2017). Moreover, it has been shown that individuals, including children and adults, experience negative health consequences as a result of exposure to air pollution, including respiratory disorders (Duflo et al., 2008) and even infant mortality (Imelda, 2020). Due to the aforementioned problems, numerous developing countries have initiated fuel conversion programmes aimed at transitioning from conventional cooking fuels to cleaner alternatives, such as liquefied petroleum gas (LPG).
The literature thoroughly documents the adoption of clean cooking fuel and its positive effects on health and the environment. However, there has been less or no focus on the immediate and direct advantage of this adoption, which is time-saving for women in terms of fuel collection, preparation, and cooking. According to Akter (2021), women and girls in both rural and urban societies often bear the responsibility of cooking. The adoption of LPG can yield significant co-benefits by alleviating the disproportionately burdensome unpaid work that women face, while simultaneously contributing to the attainment of the sustainable development goal of providing clean energy access to all individuals. Research investigating the advantages of clean cooking fuel has emphasized its long-term health benefits, which manifest over time and are not immediately obvious. The primary and readily apparent advantage of adopting LPG is its favourable impact on the well-being of women, which can be attributed to three factors: (a) decreased time spent on gathering and

preparing fuel, (b) decreased cooking duration, and (c) the convenience of the cooking setup. The scholarly literature has paid scant attention to the advantages associated with the use of LPG.

Sustainable Development Goal 7 (SDG 7) is among the seventeen Sustainable Development Goals that were adopted by the United Nations General Assembly in 2015. The objective is to guarantee universal access to inexpensive, dependable, sustainable, and contemporary energy sources. The provision of energy resources is a crucial foundation for the overall welfare of individuals, as well as for the advancement of economic growth and the mitigation of poverty. The objective encompasses a set of five specific milestones that are to be accomplished by the year 2030.The measurement of progress towards the targets is conducted through the utilization of six indicators. One of the five aims is classified as an outcome target. The objective is to achieve universal accessibility to contemporary energy sources, enhance the worldwide proportion of renewable energy, and amplify the rate of progress in energy efficiency. The two remaining priorities are to means of implementation, including the promotion of access to research, technology, and investments in clean energy, as well as the expansion and upgrading of energy services for developing nations. In alternative terms, these objectives encompass the provision of economical and dependable energy access, alongside the augmentation of the proportion of renewable energy sources within the worldwide energy composition. Additionally, there is a strong emphasis on enhancing energy efficiency, fostering international collaboration, and promoting investments in the development of sustainable energy infrastructure.

In 2016, the federal government of India established the Pradhan Mantri Ujjwala Yojana (PMUY), which is a flagship energy policy aimed at achieving SDG objective 7. The primary objective of this initiative is to ensure the well-being of women and children by offering them access to clean cooking fuel, specifically liquefied petroleum gas (LPG). This provision intends to alleviate the health risks associated with exposure to smoke in traditional kitchens and the hazards involved in gathering firewood from unsafe regions. The Pradhan Mantri Ujjwala Yojana was inaugurated by the esteemed Prime Minister Shri Narendra Modi on May 1st, 2016, at Balia, Uttar Pradesh.

Our research focuses on examining the advancements made by Indian women in achieving Sustainable Development Goal 7. Specifically, we investigate the extent to which they have transitioned from non-ecologically friendly fuels to environmentally sustainable alternatives. The central government has implemented several initiatives to facilitate the transition of rural households towards cleaner cooking fuel, such as the Pradhan Mantri Ujjwala Yojana (PMUY), which aims to promote the adoption of liquefied petroleum gas (LPG) among low-income households. We aim to assess the transition from non-environmentally friendly fuel sources to eco-friendly alternatives in India during the past decade, specifically focusing on data from the National Family Health Survey 4 (NFHS 4). Additionally, we want to forecast the likelihood of Indian women transitioning to renewable energy during the next decade, based on data from the National Family Health Survey 4 (NFHS 4). This will shed light on the tangible achievements of the Pradhan Mantri Ujjwala Yojana (PMUY) and other associated initiatives.

Literature Review

Extensive empirical investigations have been conducted in low- and middle-income nations about the relationship between solid fuels and health over several decades. Notably, Professor Kirk R Smith (1947–2020) has made significant and continuous contributions in this field. Additionally, a considerable amount of scholarly study has been conducted on the socio-economic factors and other criteria that influence fuel usage and the transition to cleaner fuel alternatives. Several literature reviews have provided comprehensive summaries of this body of research. The aforementioned significant contributions have played a crucial role in shaping comprehension and emphasizing the intricate nature of this particular discipline. Nevertheless, a significant proportion of the research conducted focused on a certain country or a particular region within a country. To illustrate, out of the 32 studies examined by Lewis and Pattanayak, just two encompassed multiple countries.

The utilization of liquefied petroleum gas (LPG) as a cooking fuel in India has shown a notable surge from the year 2015, as reported by Kapsalyamova et al. (2021). The central government introduces initiatives aimed at encouraging the utilization of LPG, based on the underlying assumption of the environmental and long-term health advantages associated with the adoption of clean cooking fuel (Goldemberg et al., 2018). According to Singh et al. (2017), empirical evidence indicates that the country witnessed a substitution of around 7.2 million tonnes of fuel wood due to the enhanced availability of LPG. This transition not only alleviated the strain on forest resources but also yielded limited climatic advantages. According to Imelda's (2020) study, the implementation of a nationwide fuel-switching programme in Indonesia aimed at substituting paraffin with LPG has resulted in a decrease in infant death rates and the occurrence of low birth weight.

In addition to transitioning from conventional fuel sources to cleaner alternatives, the adoption of liquefied petroleum gas (LPG) necessitates the replacement of traditional cook stoves with contemporary ones to handle the shift in cooking fuel. According to Baquié and Urpelainen (2017), contemporary cook stoves offer enhanced efficiency and convenience compared to their traditional counterparts. This is primarily attributed to their ability to rapidly reach high temperatures and accommodate several burners, enabling the simultaneous preparation of different food items (Jagoe et al., 2020). Contemporary cook stoves have reduced ignition time and possess superior heating capabilities compared to conventional

cook stoves. The achievement of optimal heat control in modern cook stoves involves the manipulation of burner knobs, whereas traditional cook stoves necessitate a significant investment of time and effort in managing heat, such as the addition or removal of fuel. Consequently, the utilization of LPG for food preparation yields a reduced cooking duration compared to conventional cooking fuels.

The sole research endeavour examining the association between the adoption of LPG and the well-being of women is undertaken by Malakar and Day (2020). The researchers employed a qualitative approach to conduct a comparative analysis of several areas of well-being among those who have adopted LPG as a fuel source and those who continue to use firewood. The research findings indicate that the adoption of LPG has a positive impact on the well-being of women. This is achieved through enhancements in their social standing and health, as well as the provision of time savings from culinary activities and increased options for fuel usage. The existing body of studies about the use of modern cook stoves provides evidence of the considerable time advantage experienced by women with the reduction in time required for firewood collecting (Guzmán et al., 2020; Jagoe et al., 2020). Previous research has examined various aspects associated with the adoption of clean cooking fuel. These factors include affordability (Bansal et al., 2013; Pundo & Fraser, 2006; Gould & Urpelainen, 2018), as well as household expenditure, size, and education (Rao & Reddy, 2007).

The Pradhan Mantri Ujjwala Yojana (PMUY) aims to give 5 crore LPG connections to Below Poverty Line (BPL) households within three years, with a financial assistance of Rs.1600 per connection. To promote the empowerment of women, particularly in rural areas of India, the connections would be registered under the names of the female members of the households. A total of 8000 crore rupees has been earmarked for the implementation of the plan. The process of identifying Below Poverty Line (BPL) families will be conducted using data from the Socio-Economic Caste Census. According to the Ministry of Petroleum and Natural Gas (2016), the six states included in the ACCESS study were prioritized under the PMUY programme because their pre-program LPG usage was lower than the national average. Before the implementation of the programme, individuals residing in rural areas of these states mostly depended on firewood, crop residue, and dung cake as their primary sources of cooking fuel. Conversely, the utilization of liquefied petroleum gas (LPG) as a cooking fuel was relatively restricted among urban inhabitants with intermediate to high incomes (Aggarwal et al., 2018). Nevertheless, the adoption of LPG has predominantly been constrained to urban regions and individuals with middle to high-income levels. The programme provided subsidized liquefied petroleum gas (LPG) connections to rural households that fell below the poverty line (BPL).

The primary goal of the Pradhan Mantri Ujjwala Yojana (PMUY) was to facilitate the provision of clean cooking fuel to impoverished households residing in rural areas. Additionally, it aimed to promote a shift away from conventional cooking fuels, such as firewood, coal, and cow-dung cakes (Government of India, 2021). The programme offered financial assistance to rural households living below the poverty line (BPL), specifically targeting female applicants. This assistance amounted to a subsidy of $22, which covered the costs associated with acquiring an LPG connection, including the cylinder, pressure regulator, and pamphlet. The subsidy was directly deposited into the bank accounts of the women residing in these households. Households were offered the opportunity to obtain an interest-free loan to finance the expenses associated with the installation process. According to the Ministry of Petroleum and Natural Gas (2019), a total of 72 million connections had been granted under this scheme as of July 2019.

The programme has achieved significant success in effectively reaching its intended recipients within the designated timeframe. According to the Comptroller and Auditor General of India (2019), there has been a significant rise in the adoption of LPG in rural areas of India, with the percentage increasing from 61.90% in May 2016 to 94.30% in April 2019. According to Alexander and Padmanabhan (2019), the rural regions of Bihar, Jharkhand, Madhya Pradesh, Odisha, Uttar Pradesh, and West Bengal exhibited a low level of LPG adoption in 2015, with rates below 35%. The adoption rates varied among these states, ranging from 6% in Jharkhand to 35% in Uttar Pradesh. According to Alexander and Padmanabhan (2019), the adoption rate of LPG in Jharkhand had reached 34% by 2018, whereas in Uttar Pradesh it had climbed to 47%. The significant expansion can be predominantly ascribed to the Pradhan Mantri Ujjwala Yojana (PMUY) initiative. According to the findings of the ACCESS study, it was observed that the PMUY programme accounted for 43% of the total new LPG connections in the six states under consideration. Before the implementation of the Pradhan Mantri Ujjwala Yojana (PMUY), various initiatives were implemented in India to facilitate the shift of rural households towards clean cooking fuel. One such initiative was the Rajiv Gandhi Gramin LPG Vitaran Yojana. However, it is noteworthy that none of these programmes demonstrated the same level of effectiveness as the PMUY in promoting the adoption of liquefied petroleum gas (LPG), particularly among low-income households.

The Pradhan Mantri Ujjwala Yojana (PMUY) is exclusively focused on Below Poverty Line (BPL) households. However, there was a significant rise in the adoption of Liquefied Petroleum Gas (LPG) among households that did not meet the eligibility criteria over the period from 2015 to 2018. This growth can be attributed to two primary factors. The accessibility of LPG stoves and cylinders in rural markets has witnessed a notable increase, hence facilitating the supply of LPG for both eligible and non-eligible rural households under the Pradhan Mantri Ujjwala Yojana (PMUY). Between the years 2014 and 2019, a total of around 9000 additional distributors of liquefied petroleum gas (LPG) were established, as reported by Alexander and Padmanabhan (2019). Furthermore, the adoption of LPG had a notable growth as a result of societal impact. Households adopted liquefied petroleum gas (LPG) as a fuel source in response to the adoption of LPG

by their social network, including neighbours, acquaintances, and family members (Kuo and Azam, 2019; Srinivasan and Carattini, 2020).

The implementation of the Pradhan Mantri Ujjwala Yojana (PMUY) exhibited regional disparities, with variations observed among states and districts. The program's focus was mostly directed towards the north-eastern and hilly regions, as well as those states where the prevailing utilization rate was below the national average. The differences observed in the implementation of the Pradhan Mantri Ujjwala Yojana (PMUY) at both intra-state and inter-state levels can be ascribed to factors such as population size, proportion of below poverty line (BPL) households in a particular village, and the degree of programme coverage (Srinivasan and Carattini 2020). The district- and village-level deployment in each state was set based on discretionary regulations. To implement the programme, the Oil Marketing Company designated District Nodal Officers in each district (Mhamia, 2016). Certain states implemented a strategy of prioritizing villages with a lower number of LPG connections, but other governments opted to pick villages based on their potential for LPG adoption.

Although the initial adoption of LPG through the programme showed promising results, the continued utilization of LPG posed a significant obstacle due to the limited availability of refills in remote rural areas. These regions are characterized by a scarcity of nearby LPG refill facilities, making it challenging for residents to get refills. According to a study conducted by Kar et al. (2019), the quantity of LPG refills among beneficiaries of the Pradhan Mantri Ujjwala Yojana (PMUY) was found to be less than 50% of the refills observed among non-PMUY LPG users. According to the study conducted by Mani et al. (2020), it was observed that individuals who were beneficiaries of the Pradhan Mantri Ujjwala Yojana (PMUY) were significantly less inclined to utilize liquefied petroleum gas (LPG) as their major source of fuel for cooking, as compared to non-PMUY LPG users. The availability of free biomass and fuel wood, as well as the variability of income, are significant determinants that influence the long-term utilization of LPG, as highlighted by Mani et al. (2020). The limited acceptance and insufficient long-term utilization of LPG were also impacted by the erroneous belief that the consumption of food prepared with LPG poses health risks (Vyas et al., 2020). There is a perception among certain individuals that the quality of food diminishes when prepared using non-traditional cooking methods, as shown by Vyas et al. (2020).

Objectives

It can be argued that women may exhibit a stronger inclination towards investing in cleaner fuel based on logical reasoning. Due to the predominant role of women in undertaking cooking-related duties, they are more susceptible to experiencing adverse consequences. Nevertheless, the extent to which conditions that grant women agency in decisionmaking lead to increased investments in clean fuels is a matter that requires empirical investigation. It is reasonable to anticipate that women, being disproportionately affected by the challenges of cooking in smoke-laden environments, gathering firewood, and producing cow dung cakes, will exhibit a heightened motivation to invest in cleaner fuel alternatives. However, previous research has indicated that women exhibit a stronger inclination towards prioritizing the well-being of the collective (Croson and Gneezy, 2009) compared to males. Consequently, women may potentially prioritize expenditures in other consumer products that benefit the entire household, thus disregarding their well-being.

The aim of this study is

i. To investigate if women who serve as household heads can effectively implement their preferences, and whether this implementation leads to an increased utilization of clean fuels.
ii. Examine whether there is a discernible shift in the utilization of fuel types, namely from non-eco-friendly to ecofriendly, among women in India.
iii. Determine the transition probability of the shift from the utilization of non-eco-friendly fuel to eco-friendly fuel among Indian women, spanning 10 years from NFHS 3 (2005-06) to NFHS 4 (2015-16).
iv. To assess the number of families that continue to utilize non-eco-friendly fuel at present.

Description of Variables

The utilization of solid fuels and kerosene for cooking purposes, whether through open fires or basic stoves, constitutes a significant environmental hazard concerning world health. According to the indoor air quality recommendations established by the World Health Organisation (WHO), solid fuels, which encompass coal and biomass sources including charcoal, wood, dung and agricultural wastes, as well as kerosene, are classified as 'polluting'. Conversely, fuels such as electricity, LPG (liquefied petroleum gas), biogas and natural gas are categorized as 'clean'. The available data indicates that households led by women primarily rely on a variety of cooking fuels, including firewood, crop residues, cow dung cakes, coal, lignite, charcoal, kerosene, LPG, NPG, electricity, and biogas. In our analysis, we amalgamate many types of fuel sources, including fuel, firewood, agricultural residue, cow dung cake, coal, lignite, charcoal, kerosene (considered non-environmentally friendly), as well as LPG, NPG, electricity, and biogas (considered environmentally friendly).

Materials and Methods

Data

District Level Household Survey (DLHS) data from 29 states of India, which were collected during the Third National Family Health Survey 2005-06 and Fourth National Family Health Survey 2015-16 and Fifth National Family Health Survey 2019-2021 by the International Institute of Population Sciences and ORC Macro, have been used for the present analysis. These data have been published and provided the sample for the present analysis. They include economic, regional, demographic and biosocial data on women aged 15 to 49 years.

Data Collection

A uniform sample design was adopted in all states. In each state, the rural sample was selected in two stages, with the selection of Primary Sampling Units (PSUs), which are villages, with probability proportional to population size (PPS) at the first stage, followed by the random selection of households within each PSU in the second stage. In urban areas, a three-stage procedure was followed. In the first stage, wards were selected with PPS sampling. In the next stage, one census enumeration block (CEB) was randomly selected from each sample ward. In the final stage, households were randomly selected within each selected CEB.

Model

In this paper, we used the chi-square test to know the fuel type switchingbehaviour among women.

We first test the following null hypothesis: There is no switch in the use of fuel type (non-eco-friendly to eco–friendly) among the woman's

Next, by applying a Markov Chains model, we have created a transitional matrix that shows the likelihood of moving from status i in year t-1 (NFHS -3) to status j in year t (NFHS-4).Let Xt represent the random variable that reflects a woman's fuel use status at time t. For eco-friendly fuel and non-eco-friendly fuel, we assume that Xt is discrete and has 2 unique values. We consider the first-order discrete Markov process to be how Xt generates its data:

$$P(X_t = i \,/\, X_{t-1}, X_{t-2}, \ldots\ldots\ldots, X_1) = P(X_t = i \,/\, X_{t-1}$$

Where i denotes fuel use status.

This Markov process means that the process has no recollection of the past once X_{t-1} is known. The assessment of future conditional probabilities does not take into consideration any additional past values of the process. Between time t-1 and t, the probability of changing from state i to state j is represented as

$$p_{ij}(t) = P(X_t = i \,/\, X_{t-1})$$

Here $p_{ij}(t)$ are the transition probabilities between $i, j = 1, 2$ different states. We organise the overall set of transition probabilities between fuel use states in the form of a 2 × 2 transition matrix.

Results and Findings

To determine the fuel type switching patterns of the women, we performed the chi-square test.

The following null hypothesis is first tested: The womendo not move from using non-eco-friendly fuel to eco-friendly fuel.**Table 1** represents the result of the chi-square test.

Table 1: Result of chi-square testbetween using non-eco-friendly fuel to eco-friendly fuel

χ^2 Test	
Value	**p-value**
87758.38742	< .001

We reject the null hypothesis based on the data in the table because the p-value is less than .05. The women are switching to utilising environmentally friendly fuel.

The transition probability matrix from NFHS -3 to NFHS -4 is given in **Table 2**

Table 2:The transition probability matrix from NFHS -3 to NFHS -4

	NFHS-4(2015-16)	
NFHS-3(2005-06)	Eco – friendly	Non-eco-friendly
Eco – friendly	1	0
Non-eco-friendly	0.54	0.46

It is evident from the table that 54% of the women are switching between non-eco-friendly and eco-friendly fuel throughout this time. Still, 46% of women use fuel that is not environmentally friendly.

Table 3:The transition probability matrix from NFHS-4 to NFHS-5

	NFHS-5(2019-21)	
NFHS-4(2015-16)	Eco – friendly	Non-eco-friendly
Eco – friendly	0.83	0.17
Non-eco-friendly	0.33	0.67

From **Table 3** it is clear that 33% of the women are switching from non–eco–friendly fuel to eco-friendly fuel after 5 years of NFHS-4 and 17 % of the women switching from eco–friendly fuel to non-eco-friendly fuel. The result is surprising. From NFHS 4 to NFHS 5, the percentage of Indian women switching from non-eco-friendly fuel to ecofriendly fuel (33%) decreases than previous. Moreover, 17 % of women switch from eco-friendly fuel to non-ecofriendly fuel, which is very alarming. It indicates the failure of PMUY. After the COVID-19 outbreak, the government announced nationwide lockdown leading to a disruption in social and economic activities across the country. Ownership of LPG connections has become a critical issue in rural India, which is causing social, economic, and environmental distress in everyday life, particularly for females. The impact of the COVID-19 pandemic on the clean fuel program in India highlighted the concerns of the rural population regardingthe affordability and accessibility of clean cooking fuel due to the loss of income and livelihood during the lockdown. In June 2020, the Government stopped depositing subsidies in the accounts of beneficiaries without issuing any order. In the wake of the COVID–19 pandemic and worldwide destruction of demand, the international price of crude oil and all petroleum products including LPG plummeted. People who are subsidized now becomeworse offbuying cooking fuel. In the pandemic period, they may sell off their fuel to earn money. They may switch from eco-friendly to their old system of cooking with non-ecofriendly fuel.

Conclusion

The study's finding reveals that the social benefits of clean cooking fuel adoption are been gradually recognized by Indian women. 54% of the women switchedfrom non-eco-friendly and eco-friendly fuel during NFHS 3 (2005-06) to NFHS 4 (2015 -16) i.e. 10 years. Still, 46% of women use fuel that is not environmentally friendly. It'sa huge achievement and very much supportive of achieving Sustainable Development Goals. Therefore, to avail the full potential of clean fuel adoption,more investment in all respects is highly needed. But From NFHS 4 to NFHS 5, the percentage of Indian women switching from non-eco-friendly fuel to eco-friendly fuel(33%) decreasedpreviously.
Moreover, 17 % of the women switched from eco-friendly fuel to non-eco-friendly fuel. It's a failure of PMUY of the Indian govt.

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