

Gender and LPG use after government intervention in rural north India

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Abstract

Exposure to air pollution from cooking with solid fuels has important consequences for public health. This paper focuses on rural north India, where despite robust economic growth and government subsidies, seven out of eight households mainly use solid fuels. We draw on new qualitative and quantitative data, and a recent policy environment that dramatically expanded ownership of liquid petroleum gas (LPG), to examine why households are slow to adopt clean fuels in rural north India. We find that patriarchal gender norms and attitudes encourage the use of solid fuels in this region. North Indian society confers low status to women, promotes women's seclusion, and constrains women's engagement in economic activities outside of the home. These beliefs encourage women to preserve gas, promote women's work that facilitates the use of solid fuels, and hinder communication between the cook and the decision-maker regarding LPG refills. When rural north Indian households use gas, it is frequently to facilitate the adherence to norms of seclusion that prevent women from leaving the home to collect solid fuels. Future research and policy interventions should pay careful attention to the gender norms and attitudes that discourage the use of gas. Addressing these beliefs is essential to sustained LPG use and health improvements.

Keywords: energy transition, solid fuels, LPG, gender, India

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1 Introduction

Solid fuel use for cooking is an important contributor to air pollution and disease in developing countries (Smith, 2000; Salvi and Barnes, 2009; Anonymized, 2019*c*). The combustion of solid fuels also emits carbon and other greenhouse gases that contribute to air pollution and climate change (Wilkinson et al., 2009). Because of the harmful impacts that solid fuels have on human health and the environment, the Sustainable Development Goals call for universal access to clean cooking fuels by 2030. However, despite economic development, solid fuel use persists in many developing countries in the world (Masera, Saatkamp and Kammen, 2000; Cheng and Urpelainen, 2014; Gould and Urpelainen, 2018). Why is the transition to clean cooking fuels so slow? This is the puzzle that this paper addresses in the context of India. The paper draws on recent changes in the policy environment that dramatically expanded access to clean fuels, and extensive field research by the authors in rural north India, including qualitative interviews and new quantitative data from the Survey of Rural Sanitation and Solid Fuel Use (RSFU). It examines how gender norms and attitudes related to women’s status, women’s seclusion, and women’s work explain the persistence of solid fuels.

India is a major contributor to global solid fuel use because of its population size and because solid fuels are still so commonly used. In fact, even though India’s population is about one-seventh of the world’s population, India represents about one-third of global solid fuel users (World Health Organization, 2016). Most of this occurs in rural areas. The most recent National Family Health Survey for India, which collected data in 2015 and 2016, estimated that 75% of rural households reported mainly using solid fuels for cooking.

To accelerate the transition of households from polluting to clean fuels, the Government of India launched the Pradhan Mantri Ujjwala Yojana (PMUY) in May 2016, a program that subsidized the set up costs of liquid petroleum gas (LPG) for rural households. Enrolled households also benefited from existing subsidies on cylinder refills. By the end of the program, in September 2019, the government claimed that 80 million connections had been subsidized. Indeed, in our novel survey data, 72% of households owned an LPG stove in 2018. Ujjwala rapidly changed the cooking fuel choice set for rural Indian households. However, households often use multiple fuels for cooking, and the vast majority of owners of LPG stoves continue to use solid fuels regularly (Jain et al., 2018; Anonymized, 2019*a*; Kar et al., 2019).

This paper aims to understand why the use of solid fuels for cooking persists in rural north India. We begin by presenting a puzzle: among households owning the same number of assets, solid fuel use is much more common in rural north India compared to rural south India. Even

though Ujjwala dramatically expanded ownership of LPG stoves and access to LPG subsidies, rural north Indian households continue to use solid fuels (Alexander and Padmanabhan, 2020). A difference between north and south India is how vigorously patriarchy is practiced. Indeed, our main findings highlight the importance of the gender context for cooking fuel use. Based on our novel qualitative and quantitative research in rural north India, we find that north Indian gender norms and attitudes encourage women to preserve gas, promote women’s work that facilitates the use of solid fuels, and hinder communication between the cook and the decision-maker regarding LPG refills. The cooking practices of households that do regularly use LPG can also be understood in the context of gender; using gas facilitates the adherence to norms of seclusion that prevent women from leaving the home to collect solid fuels.

A growing literature links intra-household gender inequalities to the continued use of solid fuels. In rural north India, women are primarily responsible for cooking and preparing solid fuels (Hirway and Jose, 2011; Sharma, 2018; Anonymized, 2019a), but men are often the financial decision-makers in the household (Palriwala, 1993; Desai et al., 1994). Since men may not fully appreciate the benefits of cooking on gas, they may not value refills as highly as women who cook. Indeed, Gould and Urpelainen (2019) find that households in which women participate in decision-making are more likely to adopt LPG. Research by Choudhuri and Desai (2020) supports this finding, and adds that women’s access to salaried work is also associated with the use of clean fuels. Kishore and Spears (2014) use a different measure for women’s status, the sex of her first child, since son preference conveys higher status to women whose first child is male. They find that urban households in India with a male first child are more likely to use clean cooking fuel than similar households with a female first child. Other studies find that women-headed households in South Asia are more likely to use LPG (Das et al., 2014; Behera et al., 2015; Mottaleb, Ali et al., 2017). This literature examines discrete measures of women’s status, and quantitatively studies their associations with the use of clean cooking fuels.

More broadly, the development literature has identified a number of cases where gender norms, attitudes, and beliefs shape population health outcomes. In an influential study on routes to low mortality in developing countries, Caldwell (1986) identified women’s autonomy as a “central” feature of mortality decline in poorer societies. In India, poor maternal nutrition, an outcome of young married women’s low status, is an important reason why neonatal mortality in India is so high compared to other even less developed countries in the world (Das Gupta, 1995; Coffey and Spears, 2019). Similarly, the highly imbalanced sex ratio and millions of “missing women” in India is a result of the widespread preference for sons (Sen, 2003).

Our study contributes to this diverse literature in several ways. First, by integrating qualitative and quantitative interview data, we present a coherent analysis of the multiple ways that gender norms and attitudes shape household cooking fuel decisions. Patriarchal beliefs and practices in rural north India encourage women to preserve gas, promote women’s work that facilitates the use of solid fuels, and hinder communication between the cook and the decision-maker regarding LPG refills. Our comprehensive treatment of gender uncovers the mechanisms underlying correlations between gender indicators and fuel use, and makes a unique contribution to this literature. Second, we contribute to an emerging literature on LPG use rather than use of clean cookstoves or LPG ownership, and we speak to the clean fuel policy challenge that India now faces. The prior literature on cooking practices in India cited above was carried out before the Ujjwala Yojana started, when only a minority of rural households had an LPG connection. Now, the majority of rural Indian households have the infrastructure to cook with LPG. That few consistently use it reveals the importance of gender norms and attitudes in cooking practices. Finally, our study contributes to the wider literature on the persistence of poor health in India despite robust economic growth. We reinforce the message in the prior literature that gender norms and inequalities pose important barriers to health improvements.

The paper proceeds as follows. Section 2 presents a puzzle: low economic status cannot fully explain the persistence of solid fuels for cooking in rural north India. It also describes the gender context which shapes household decisions on cooking fuels in rural north India. Section 3 describes the original quantitative and qualitative data sources and the methods we use to study why rural north India lags in the adoption of clean fuels. Section 4 presents facts about LPG ownership and use after Ujjwala in rural north India: LPG ownership has dramatically increased as a result of the program, but many households continue to use solid fuels. Section 5 characterizes the ways in which gender norms and attitudes discourage the use of gas in rural north India. Section 6 considers the few households that do regularly use gas, and discusses how gender norms and attitudes plays a role in explaining at least some of the regular use that exists. Finally, Section 7 concludes with a discussion of these findings in the context of research and public policy.

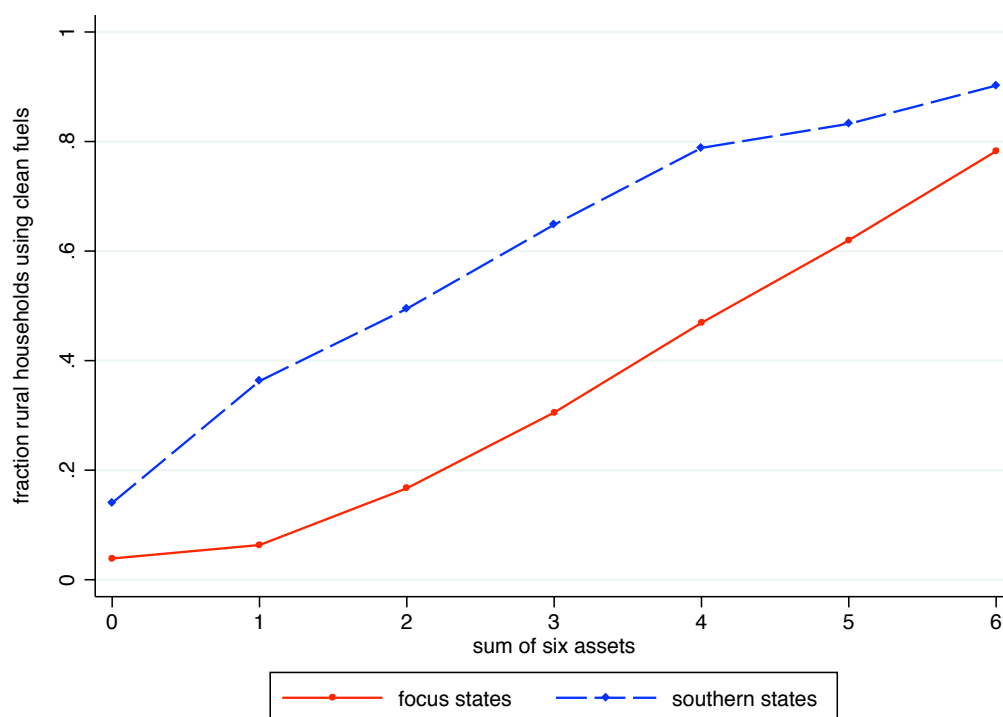
2 Background

2.1 The puzzle of slow clean fuel adoption in rural north India

The use of solid fuels persists throughout rural India, but is especially enduring in rural north India. Only 14% of households in rural Bihar, Madhya Pradesh, Rajasthan, and

Uttar Pradesh, together called the focus states, were recorded as mainly using clean fuels for cooking in India's NFHS 2015-2016.¹ This is much lower than the rural India average of 24%. Part of this difference between the focus states and the rest of India may be because of differences in economic status; rural north India is poorer, on average, than other parts of the country. For example, 56% of households in the focus states defecated in the open, while 40% of households in other states did. We investigate the extent to which differences in socioeconomic status can explain differences in clean fuel use in Figure 1.

Figure 1: Greater rural clean fuel use in southern states compared to the focus (northern) states, at every level of asset wealth



The figure shows the fraction of rural households using clean fuels in the focus states, shown in red, and the southern states, shown in blue, at different levels of asset wealth. Focus states include Bihar, Madhya Pradesh, Rajasthan, and Uttar Pradesh. Southern states include Andhra Pradesh, Karnataka, Kerala, Tamil Nadu, and Telangana. Clean fuels include electricity, LPG, and biogas. Assets include radio, television, refrigerator, bicycle, motorcycle, and car. Estimates use sample weights. Source: India's National Family Health Survey 2015-2016.

Figure 1 plots the fraction of households that use clean fuels in the focus states, and in a number of south Indian states, at different levels of asset wealth. The six assets used in

¹Because the Ujjwala Yojana was launched in May 2016, most of the data collection for the NFHS occurred before the beginning of the program.

this figure include radio, television, refrigerator, bicycle, motorcycle, and car. The horizontal axis is a simple sum of asset ownership. The focus states are shown in red and the southern states are shown in blue. The upward slope of these lines suggests that wealth plays a role in cooking fuel decisions. However, at every level of asset wealth, a substantially smaller fraction of rural households in the focus states used clean fuels compared to rural households in the southern states. The difference between the focus states and the southern states provides evidence that low economic status cannot fully explain the slow adoption of clean fuels in rural north India. Why does solid fuel use persist in rural north India, when similarly poor rural households in other parts of the country have adopted clean fuels at greater rates?

Table 1: Higher status for rural women in southern vs. northern states

sample:	India's NFHS 2015-2016		
	focus	southern	all
	states	states	india
	(1)	(2)	(3)
mainly uses clean fuel (LPG, electricity, biogas) for cooking	0.14	0.50	0.24
mainly uses LPG for cooking	0.14	0.48	0.23
sum of six assets	1.61	2.12	1.83
usually allowed to go alone to:			
market	0.41	0.55	0.50
health facility	0.38	0.50	0.46
out of village	0.39	0.48	0.46
respondent participates in decisions on:			
how husband's earning will be used	0.70	0.69	0.70
major household purchases	0.67	0.73	0.72
health care for respondent	0.70	0.72	0.74
visits to your family or relatives	0.66	0.75	0.73
husband has never used violence with respondent	0.61	0.64	0.66
does respondent do work aside from housework	0.29	0.41	0.33
respondent's years of education	4.91	6.79	5.83

Focus states include Bihar, Madhya Pradesh, Rajasthan, and Uttar Pradesh. Southern states include Andhra Pradesh, Karnataka, Kerala, Tamil Nadu, and Telangana. Assets include radio, television, refrigerator, bicycle, motorcycle, and car. Estimates use sample weights. Data from India's National Family Health Survey 2015-2016.

Another difference between the focus states and India's southern states relates to women's autonomy (Dyson and Moore, 1983; Jejeebhoy and Sathar, 2001; Rahman and Rao, 2004). Table 1 presents statistics on different measures of women's autonomy in the focus states and southern states from the NFHS. A greater fraction of rural women in southern states compared to the focus states were allowed to go alone to a market, health facility, and out of the village. Although the differences are smaller, a greater fraction of rural women in southern states compared to the focus states also participated in decisions on major household purchases, health care for herself, and visits to her family or relatives. Rural

women in southern states were less likely to face violence from their husbands, and more likely to do work aside from housework, compared to rural women in the focus states. This table provides suggestive evidence that the more patriarchal gender attitudes in rural north India may play a role in its slow adoption of clean fuels. The next section summarizes the literature on gender norms and attitudes that are relevant for understanding cooking fuel use in rural north India.

2.2 Cultural context

The work of cooking is almost always done by women in rural north Indian households (Hirway and Jose, 2011; Anonymized, 2019a), while financial decisions are almost always made by the male household head (Palriwala, 1993). An understanding of cooking practices therefore relies on the gender context in rural north India. In this section, we draw heavily on prior social science research investigating women’s status, seclusion, and work in India to provide background for our findings.

Women’s status and seclusion. Mandelbaum (1988) and Jeffery, Jeffery and Lyon (1989) explain how household hierarchies impose restrictions on young women. A young bride normally starts her married life in a multi-generational household with her husband’s parents. She is closely monitored by her mother-in-law and other more senior daughters-in-law, and is expected to behave with deference and restraint, particularly around the male elders in the family. Initiating conversation with her father-in-law or her husband’s elder brothers is considered inappropriate and unacceptable. Indeed, she would signal her respect for more senior family members by remaining secluded from males, and practicing *purdah*, which refers to covering the face or head with a veil. Her movements outside of the home are also heavily controlled.

As a woman ages and has children, her status in the household improves and she is likely to reduce some of her veiling, such as in front of her mother-in-law. However, a woman should never stop sending signals of deference in front of her father-in-law and husband’s elder brothers. Eventually, a woman and her husband may separate from the joint family, and her husband will become the household head. In a nuclear household, a woman may have substantially more voice and autonomy since the elder males, for whom deference and practices of seclusion are most important, no longer reside in the same household. Das Gupta (1995) contends that although new daughters-in-law are expected to behave with great reserve and have very little autonomy, senior women can wield considerable influence in domestic matters. Indeed, an older woman does not face the same constraints on behavior as a younger woman because the number of people superior to her in the household hierarchy

is necessarily less.

Women’s work. A consequence of women’s seclusion is that working for pay outside of the home is highly curtailed. Labor force participation among women in India is remarkably low, and has been declining over time despite increases in women’s educational attainment, reductions in fertility, and economic growth (Afridi, Dinkelman and Mahajan, 2016). Srinivas (1977) and Kapadia (1995) argue that there is a widespread belief, among rich and poor alike, that women working for wages is a mark of low status, and that women staying at home is preferred. Indeed, about half of adults in Delhi, Mumbai, Rajasthan, and Uttar Pradesh disapproved of women working outside of the home in a 2016 survey on social attitudes (Coffey et al., 2018).

Women in rural north India, however, do a considerable amount of unpaid manual work. Within the home, they are responsible for cooking, serving food to household members, collecting and preparing solid fuels, cleaning and grinding grains, fetching water, cleaning and maintaining the house, washing clothes and dishes, and caring for children and the elderly, among other responsibilities. Outside of the home, they may collect fodder for cows and buffaloes that their household owns, manage the animals, and participate in certain aspects of agriculture on the household farm. In joint households in rural north India, daughters-in-law of the household head are more likely to do the inside work like cooking and caring for children, and wives and unmarried daughters of the household head, for whom seclusion is less important, are more likely to do the outside work like collecting fodder and caring for animals (Jeffery, Jeffery and Lyon, 1989).

An important domestic responsibility among women, particularly senior women, is maintaining control of household stocks. In her research in rural Rajasthan, Palriwala (1993) often heard the saying: “a household was made or broken by the skill and thrift of its womenfolk in managing household stocks” (p. 57). She argues that a woman’s personal status depends on her reputation as a skilled housewife, which requires prioritizing “family good” (p. 68) over spending resources on herself. An example of the expectation for women to prioritize others over herself is that women, and especially the cook, will often eat last, after the men and children.

Animal husbandry is one of the few types of labor that can generate marketable products that is permissible for women within rural north Indian patriarchal norms. This type of work is acceptable because it would not require interaction with males outside of the household or the village. Households that own cows or buffaloes need to feed them, milk them, collect their dung, make dung cakes, and make milk products. Although the division of animal husbandry responsibilities among women and men depends on household economic status and the status and seclusion practices of the women in the household, women’s workload is

substantially heavier in households that own cows and buffaloes compared to those that do not (Jeffery, Jeffery and Lyon, 1989).

Some rural woman do participate in wage labor outside of the home. These are generally women from poor households that require additional earnings for survival. A woman who works outside of the home cannot be as closely monitored as a woman who does not, but she is still likely to veil in the presence of an elder male from the village. Nevertheless, Mandelbaum (1988) argues that women who receive wages for their own work are likely to have more personal independence than do women without such income. Whether or not this is true, a woman who works outside of the home cannot remain in seclusion, and therefore certain gender practices like staying within the home would not be expected of her.

Despite rural Indian women having very heavy work burdens, they receive very little credit from men. Jeffery, Jeffery and Lyon (1989) explain the widely perceived notion among rural north Indian men that women do no work. They document numerous conversations in which men express their belief that women spend much of their time relaxing, do nothing economically important, and simply consume household resources. There is, therefore, little value placed on women’s labor, despite its importance to a household’s prosperity.

The cultural context that we have outlined here is important background for the novel arguments that we will make in Sections 5 and 6. Young women have very low status in rural north Indian households. They are expected to practice *purdah* and participate in economic activities that allow them to maintain seclusion as much as possible. As we will argue in later sections of this paper, these beliefs encourage women to preserve gas, promote women’s work that facilitates the use of solid fuels, and hinder communication between the cook and the decision-maker regarding LPG refills.

3 Data and methods

The main analyses in this paper draw on original qualitative and quantitative interviews conducted by a team of researchers that included the authors. Both surveys collected data in the rural parts of four north Indian states: Bihar, Madhya Pradesh, Rajasthan, and Uttar Pradesh. The quantitative survey visited households in 2018, and the qualitative survey visited households in 2020. Importantly, these surveys were carried out after the Government of India introduced its program to subsidize the setup costs of LPG for rural households. Ethical approval for both the quantitative and qualitative studies was obtained from the Institutional Review Board of the authors’ institution.

3.1 Quantitative data: Survey of Rural Sanitation and Fuel Use

The main quantitative data source used in this paper is the 2018 Survey of Rural Sanitation and Fuel Use (RSFU), which is the second round of a panel survey that originally visited households in rural north India in 2014. Table 2 describes the sampling of households and villages for the 2018 survey. The survey visited 11 districts in total, two in Rajasthan, and three in each of Bihar, Madhya Pradesh, and Uttar Pradesh. Within these districts, villages were randomly selected from the villages visited in the Government of India’s District Level Household and Facility Survey 2 using probability proportionate to population size sampling. The survey team selected households within villages using an in-field randomization technique used in other large sample surveys in rural India (Banerji, Bhattacharjea and Wadhwa, 2013).² The 127 villages visited in 2018 were a random sample of villages from the first round of the panel. The survey team attempted to revisit all of the original survey households in these villages, and was successful in interviewing 88% of them. The 2018 survey also contained a refresher sample, which represented 22% of the total 2018 sample of households.³ In total, the 2018 survey collected data from 1,550 households. Questionnaires and data for the 2014 and 2018 surveys can be accessed on —.

Table 2: Quantitative and qualitative survey samples

	focus states	Bihar	Madhya Pradesh	Rajasthan	Uttar Pradesh
	(1)	(2)	(3)	(4)	(5)
Quantitative survey, 2018 (Rural Sanitation and Solid Fuel Use Survey)					
total households visited	1,550	367	459	241	483
total villages visited	127	30	38	27	32
Qualitative survey, 2020					
total households visited	45	12	13	11	9
number of agencies used in household sampling	12	3	4	3	2
total villages visited	21	6	7	3	5

See Section 3 for a discussion of sampling of quantitative and qualitative data.

Measuring fuel use. An important feature of our data is that it differentiates LPG ownership from use. Both the 2014 and 2018 surveys collected data on the types of stoves that households own, including a *chulha* (traditional stove that uses wood or cow-dung), and a stove that uses LPG. In the 2014 questionnaire, fuel use was measured using the question:

What do you use most for cooking?

²Sampling is discussed in detail in Anonymized (2014) and Anonymized (2019b).

³See Anonymized (2019b) for a discussion on how the refresher sample was selected.

The answer options for this question were: electricity, LPG, kerosene, wood/cow-dung, and no cooking in the house. We classify the response “LPG” as exclusively using LPG.⁴

The 2018 survey collected far more detailed information on fuel use. We use two different measures of fuel use from the 2018 data. The first and main measure is the number of LPG cylinders a household uses per month per person. We calculate this measure based on the answer to the question:

About how much time does one cylinder last in your house? How many days or months?

Using the number of household members, we calculate the number of LPG cylinders per month per person for each household.⁵ Households that do not have an LPG stove are assigned a value of zero. This measure captures LPG use because a cylinder would last less time in a household that uses gas more often. This measure does not, however, capture the fact that households do not always get the cylinder refilled immediately after it empties. Dabadge (2018) estimates that one LPG cylinder would be expected to last a household with five members about one month. We can therefore compare a household’s measure of gas use to a benchmark value of 0.2 LPG cylinders per month per person, the level of use that would be expected if a household were to regularly use gas.

A secondary measure is based on the cooking practices of the household the day before the survey. We first asked respondents, which were in most cases adult female household members, to report on which items, among the following, had been cooked the day before the interview: *roti* (or flatbread), rice, vegetables, lentils, tea, and boiled milk. Of the items that had been cooked the day before the interview, the surveyor asked the respondent whether the item had been cooked on the gas stove, or on the *chulha*. We code households that cooked on LPG everything they made the day before the survey as exclusively using LPG.⁶

The analyses presented in this paper primarily use the second round of the RSFU panel because it was carried out after Ujjwala, and because it contains a detailed module on fuel

⁴We recognize that mostly using LPG does not necessarily mean that the household exclusively uses it. Some households may use gas to cook the food they eat, but use the *chulha* to boil water for bathing. Similarly, households that normally use gas might use the *chulha* if they were expecting many guests, or were having a party. Therefore, we likely overestimate true exclusive LPG usage in 2014. The same caveats apply to exclusive LPG use in 2018.

⁵We count adults and children in the same way, since the comparison measure of 0.2 LPG cylinders per month per person (described in greater detail later in this paragraph) is for the average Indian household, which contains five members, including both adults and children.

⁶Households that normally use *chulha* may sometimes use gas to cook on a particular day because of rain or for some other reason. And households that normally use gas may sometimes use *chulha* on a particular day because they have run out of gas, or are expecting guests. Therefore, the variable we construct is an imperfect measure of exclusively using gas. Anonymized (2019a) shows the summary statistics from the individual questions.

use which can be used to estimate LPG use along a spectrum of fuel mixing. The only analysis that uses both rounds of the panel is Figure 2, which presents descriptive statistics of LPG ownership and use before and after the government program.⁷

Other variables. The 2018 RSFU also collected a rich set of variables on asset wealth, household size, access to solid fuels, and the main cook’s relationship to the household head. Asset wealth includes ownership of six assets, including television, fan, mixer, pressure cooker, motorcycle, and refrigerator. Access to solid fuels includes ownership of animals (including cows, buffaloes, and goats) and cultivation of land.

3.2 Qualitative data

Two of the authors carried out qualitative work in the same region visited by the quantitative survey. Our objectives were to 1) provide context for LPG use in rural north India, 2) study intra-household decision making regarding gas refills and cooking fuel use, and 3) investigate links between households and the gas distribution supply chain. Table 2 presents summary statistics on the number of households interviewed in each state. The qualitative data consists of 45 semi-structured interviews with households who recently refilled an LPG cylinder and 13 semi-structured interviews with gas distributors. We also accompanied three drivers of gas delivery vehicles on their daily rounds to deliver cylinders to customers.

Sampling for qualitative field work. We revisited one RSFU district in each of the four states. We purposively selected these districts in order to maximize variation in LPG use and indicators of women’s status from the National Family Health Survey 2015-2016, and to ensure that each of the four states was represented. Within each district, we purposively selected at least six gas distributors to ensure that the three main gas companies (Bharat Gas, Hindustan Petroleum, and Indane) were equally represented and to maximize geographic coverage of the district. We then split these six distributors into two groups, stratifying by gas company. We conducted semi-structured interviews with one group of distributors, and from the other group of distributors, we requested a list of households who recently refilled an LPG cylinder.

About half of the households we spoke to were sampled from the lists we acquired from distributors, and half were LPG-owning households living in the same villages, that were randomly selected using an in-field randomization procedure. Similarly, about half of the interviews were conducted with households that reported mainly using solid fuels, and half were with households reporting that they mainly used gas.⁸ For the in-field randomiza-

⁷See Anonymized (2019a) for a description of the 2014 sample.

⁸Near the beginning of the qualitative interview, we asked households: “In your household, what type of fuel do you mainly use for cooking food?” The purpose of this question was to ensure that our sample

tion procedure, we began by walking around the village and creating a map that divided the village into different sections. Some of these sections were already visited to interview households from the agency list. We did not revisit these sections when interviewing randomly selected households. Among the remaining sections, we randomly selected a new section to visit. In the approximate center of each section, we spun a spinner which indicated the direction we would proceed. We then randomly drew a number between one and ten which indicated how many households to pass before stopping at a household and requesting an interview. After completing an interview in the section, we randomly selected another section which had not yet been visited to conduct another interview. If no one was home in the selected household, if household members refused to participate, if the household did not own gas, or if we had already interviewed enough households of that household’s type (mainly uses gas versus mainly uses solid fuels), we knocked on each door to the selected household’s right until we found an appropriate household to interview.

Interviews. Within households, we interviewed the household members that did most of the cooking. Other household members were often present during the interview, and their opinions were also sought. The semi-structured interview guide asked questions relating to the household’s last LPG refill, daily cooking fuel decisions, and opinions of different household members regarding gas and solid fuels. This guide was developed based on an initial analysis of the quantitative data, which highlighted areas we sought to explore further in qualitative interviews. We asked mainly open-ended questions and encouraged respondents to give in-depth responses. We also asked quantitative-style questions that helped us understand household structure and socioeconomic status. In order to facilitate analysis afterwards, we recorded interviews with the respondents’ permission. 44 out of 45 interviews were recorded. For the one respondent that declined to have the interview recorded, we took more detailed written notes. We piloted the guide extensively in a non-sample district of Bihar. Although we did not sample our respondents by caste or religion, our qualitative sample was as diverse as the quantitative sample. More than half of the interviews were in households that belonged to the Other Backward Class category, and about one-third were in households that identified as Scheduled Caste or Scheduled Tribe. Other household members apart from the main respondent participated in 38 of 45 surveys.

Our observations from interviews where other household members participated often allowed us to observe household dynamics, women’s agency, and interactions among different household members. We were also able to observe disagreements within household members.

included households that used LPG to varying degrees. Sometimes this question was answered by household members who did not cook, and therefore sometimes the answer to this question was not consistent with answers to a series of other questions around fuel use provided by the cook.

In the field, our identity was that of students and researchers who were trying to understand village life in general and fuel use in particular. We were seen as outsiders, people who live in urban areas, and people without much exposure to village life. People assumed that we did not know how to cook on a *chulha*. Even though our exposure to rural north Indian villages was greater than what people assumed, we did not correct the impression that people had of us. This often meant that people took keen interest in explaining many routine aspects of fuel use to us. We conducted interviews until we felt that we had achieved saturation in terms of meanings and theoretical insights (Hennink, Kaiser and Marconi, 2017), when we felt that we were not learning new themes from additional interviews.

Measuring fuel use. To measure LPG use, we asked households to show us the LPG booklet given to them by the gas distributor. Whenever a household gets a refill, the distributor or delivery person (man) writes the date in the household’s booklet. Whenever possible, we wrote down the past two refills from this booklet. Sometimes, households did not have their booklet, did not know where it was, or did not want to show it to us. In those cases, we calculated the length of time between refills based on the respondent’s account of the past two refills. When households did not remember the approximate dates of the past two refills, we estimated the length of time between refills based on the household’s response to the question: “How often do you refill the cylinder?” These questions aided us in constructing the number of LPG cylinders per month per person for each household. The difference between this measure of use and the measure of use from the quantitative data is that this measure of use includes the amount of time it takes for a household to use up a cylinder, and also the time it takes to get it refilled after it becomes empty. This measure is therefore likely to be more accurate than the measure from the quantitative data.

3.3 Other data sources

For various supporting analyses, we draw on two publicly available nationally-representative datasets. The first is the India Human Development Survey (IHDS), a panel survey which visited approximately 42,000 households in 2005 and again in 2011-2012. The IHDS includes questions that differentiate LPG ownership from LPG use. However, both rounds of this panel survey were conducted before the Government of India launched its LPG program, and therefore before the expansion in LPG ownership. The second nationally-representative survey we use is India’s National Family Health Survey 2015-2016 (NFHS), a cross-sectional survey which visited approximately 600,000 households. Although Ujjwala started while NFHS survey teams were collecting data, the NFHS does not differentiate between LPG ownership and LPG use, and simply asks households the type of cooking fuel it “mainly

uses.”

3.4 Methods

Quantitative data analysis. We rely on data from the IHDS and NFHS to contextualize the states where this survey was done, and to motivate our paper’s findings. The bulk of the quantitative analyses presented in this paper are based on the RSFU. These analyses use sample weights constructed based on the 2011 Census of India. Households in the sample are re-weighted based on household size, to be representative of the rural population of households in these four states. Using the IHDS, we compare changes in LPG use in all states between 2005 and 2012. We compliment this analysis with the RSFU, with which we are able to examine changes in LPG use between 2014 and 2018 from the two survey rounds. Using the RSFU, we also examine the extent to which wealthier households are more likely to use LPG, the extent to which access to solid fuels influences LPG use, and the extent to which a woman’s status within the household influences LPG use. We use descriptive statistics and linear regressions. We cluster our standard errors at the level of the primary sampling unit (village).

Analysis of qualitative data. After each day of interviewing during the qualitative work, authors met to discuss the day’s interviews. We tried to reach consensus about how much a household used gas for cooking and why. We also wrote detailed observations on how the respondent interacted with us, and with others in her family. Based on the recording and notes taken on the discussion guides, one of the authors completed a detailed summary for each interview. These were then read and reviewed by the other authors, and in many cases, the authors also listened to one another’s recorded interviews. Meeting about, writing, and reviewing summaries from early interviews allowed us to identify themes, develop hypotheses, and test those hypotheses in future interviews. Following an iterative process, we changed the interview guide in small ways over time to accommodate new questions and ideas. We also kept tabulations related to the themes that arose during the interviews. For example, some of the tabulations related to primary reasons for using gas, decision-makers for the last LPG refill, the intra-household status of the main cook, who makes and collects solid fuels, and whether anyone in the household objected to using gas or getting a refill.

To code information from the interview recordings and our interview notes, we created a thematic note-taking guide. For each interview, we organized our notes and observations from the interview recording and summary based on themes. This thematic guide allowed us to observe the themes that were present in multiple interviews. We also recorded any exact quotes from our interviews in this thematic guide. For the analysis, the authors

went through the recordings, summaries, and thematic guide multiple times. In developing theoretical insights, we looked for contradictory and conflicting evidence, and analyzed how it modified our theoretical insights. This helped us make sense of the fuel use we did observe.

4 LPG ownership and use in rural north India after Ujjwala

Figure 2 shows LPG ownership and use among rural households in two panel surveys in India: data for panels A and B are from the India Human Development Survey (IHDS), which visited households before Ujjwala, and data for panels C and D are from the Survey of Rural Sanitation and Fuel Use (RSFU), that surveyed households before and after Ujjwala’s implementation. Estimates for each state are shown separately. Panel A shows LPG ownership in 2005 and 2012. As is evident from the proximity of each state to the 45 degree dashed line, increases in rural LPG ownership over this period of time were small. Bihar, Madhya Pradesh, Uttar Pradesh, and Rajasthan, the focus states visited in the RSFU Survey (and shown in red in the figure), are all clustered in the bottom left, indicating that these four states were farther behind other states in LPG ownership in both survey years. Panel B shows exclusive LPG use in 2005 and 2012. In most Indian states, exclusive LPG use did not change much between 2005 and 2012, which is indicated by most Indian states appearing either on the 45 degree line or very near it. In the focus states, hardly any households exclusively used LPG in either panel round.⁹

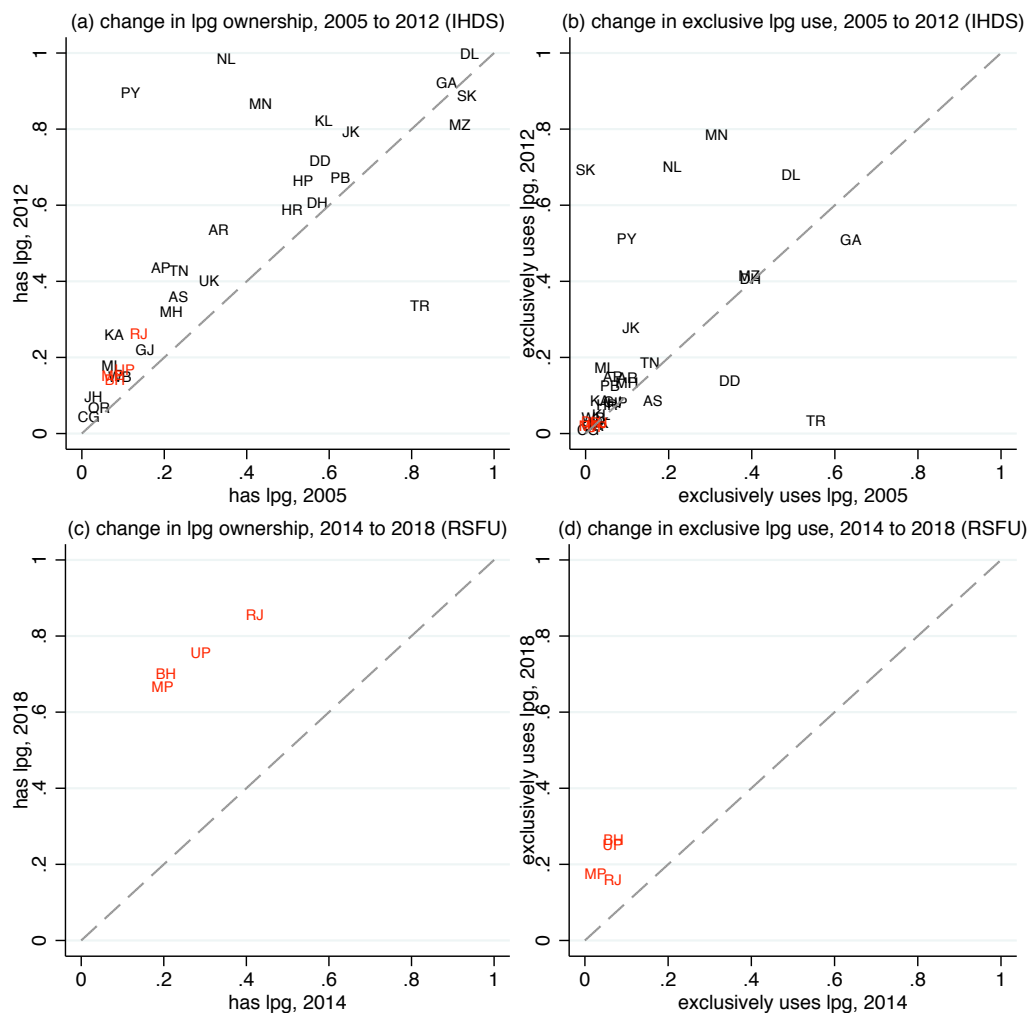
Has Ujjwala contributed to increases in rural LPG ownership and exclusive use? Panels C and D suggest that it has.¹⁰ Panel C shows LPG ownership in 2014 and 2018.¹¹ Between

⁹LPG ownership in both rounds of the IHDS is estimated from the answer to the question: does your household use LPG? This potentially underestimates the fraction of households that have an LPG stove because it is possible that some households have an LPG cylinder and stove, but use it very irregularly. Our field experience suggests that this would have been uncommon, however, since demand for LPG would have had to have been high enough to overcome the substantial investment in obtaining LPG. Regardless, since estimates from 2005 and 2012 are generated using the same questions, comparisons across years or across states would not be affected by any bias in our measure of LPG ownership as long as the bias is constant across states and over time. The IHDS also asked households whether they used firewood, dung cakes, or crop-residue for cooking, in three separate questions. We classify households as using LPG exclusively if they are coded as using LPG, and coded as not using any of the three types of solid fuels.

¹⁰How LPG ownership and exclusive use is estimated from RSFU survey questions is described in detail in Section 3.1.

¹¹LPG ownership in 2014 in Bihar, Madhya Pradesh, Rajasthan, and Uttar Pradesh, estimated using RSFU data, is higher than what would have been predicted by the annual rate of change estimated between 2005 and 2012 for each state from the IHDS. This could be for at least two reasons. First, districts visited in RSFU may not have been representative of LPG ownership in each state, because they were selected based on sanitation trends. Second, differences in the estimation of LPG ownership may arise from differences in survey questions. Sampling and survey questions for the RSFU is discussed in detail in Section 3.1.

Figure 2: Large increases in rural LPG ownership and use from 2014 to 2018 relative to the past



The figure shows change in LPG ownership and exclusive use in two panel surveys. Changes over time from the India Human Development Survey, which collected data in 2005 and 2011-2012, are shown in panels A and B, and changes from the Survey of Rural Sanitation and Fuel Use (RSFU), which collected data in 2014 and 2018, are shown in panels C and D. Panels A and C show changes in LPG ownership between the two rounds of the panel surveys, and panels B and D show changes in exclusive LPG use. LPG ownership in both rounds of the IHDS is estimated from the answer to the question: does your household use LPG? The IHDS also asked households whether they use firewood, dung cakes, or crop-residue for cooking, in three separate questions. IHDS households are classified as using LPG exclusively if they are coded as using LPG, and coded as not using any of the three types of solid fuels. LPG stove ownership in the RSFU was directly measured in both 2014 and 2018. In the 2014 RSFU, we classify households as exclusively using LPG if their response to the question, ‘What do you use most for cooking?’ was ‘LPG.’ In the 2018 RSFU, we classify households as exclusively using LPG if they used LPG to cook all of the items about which we inquired, the day before the survey. The states shown in red are the four states visited in the RSFU, including Bihar, Madhya Pradesh, Rajasthan, and Uttar Pradesh. Estimates use sample weights. Source: India Human Development Survey and Survey of Rural Sanitation and Fuel Use.

these two years, LPG ownership increased substantially in all four states, as indicated by the distance of each state from the 45 degree line. Panel D also shows changes, although more modest, in exclusive LPG use. Comparing panels C and D to panels A and B shows higher rates of change between the 2014 to 2018 period, as compared to the 2005 to 2012 period. This suggests that Ujjwala contributed to an acceleration, though modest, in the rate of change in LPG ownership and exclusive use.

Table 3: Summary statistics for quantitative and qualitative samples

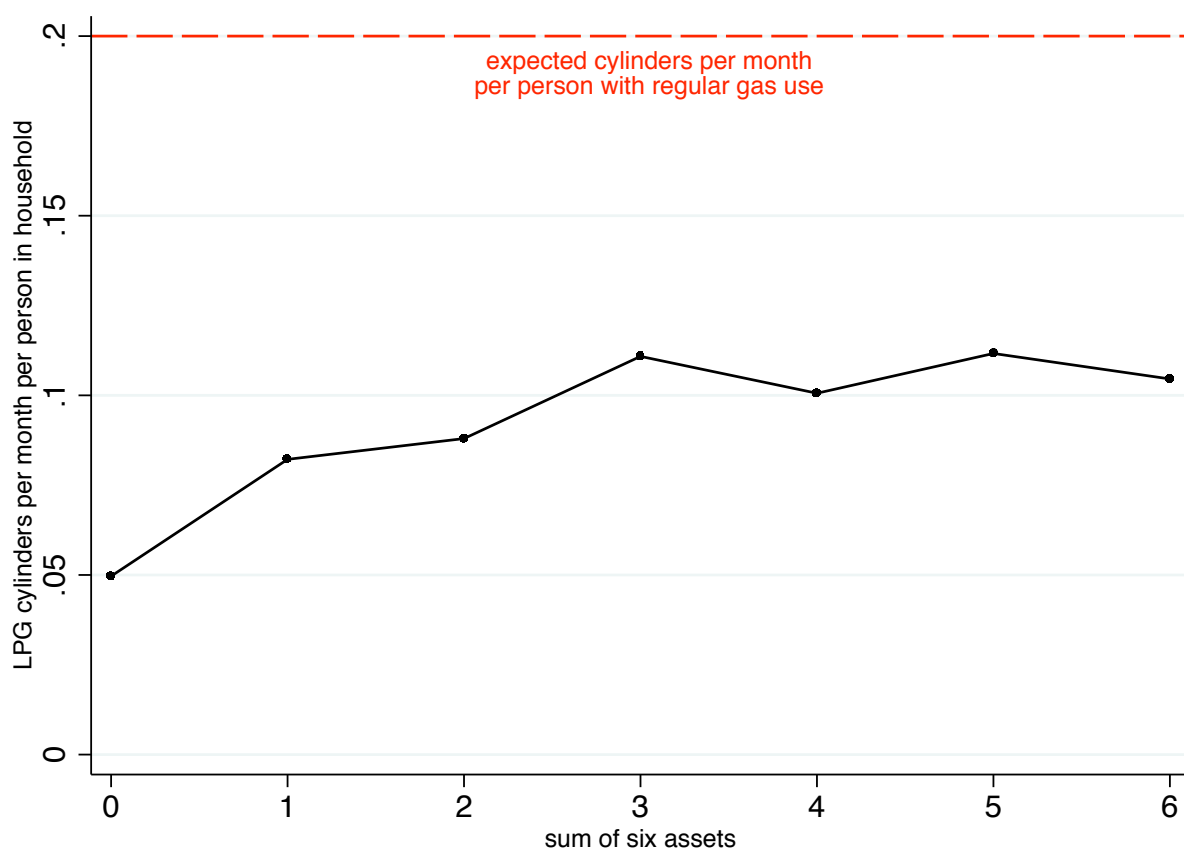
sample:	quantitative (RSFU 2018)	qualitative
has LPG	0.72	1.00
LPG cylinders per month per person	0.09	0.08
sum of six assets owned	2.50	3.16
main cook is wife of household head or household head	0.46	0.49
main cook is daughter-in-law of household head	0.36	0.40
owns animals	0.70	0.64
cultivates land	0.79	0.82
Ujjwala recipient	0.26	0.58
household size	5.70	5.96
SC/ST	0.27	0.29
OBC	0.46	0.53
n (households)	1,419	45

In the quantitative survey, LPG cylinders per month per person is estimated from the answer to the question: About how much time does one cylinder last in your household? Households that do not own an LPG stove are assigned a value of zero. In the qualitative survey, cylinders per month per person is estimated from the dates of the past two refills, if available, or the answer to the question: How often do you refill the cylinder? Cylinders per month per person is missing for 131 households in the quantitative survey, which is why the number of households interviewed in the quantitative survey and included in calculations for this table is 1,419 instead of 1,550. Assets include television, fan, mixer, pressure cooker, motorcycle, and refrigerator. The main cook is herself the household head in 40 households, and is the wife of the household head in 476 households. In the quantitative survey, “owns animals” refers to owning cows, buffaloes, and goats. In the qualitative survey, “owns animals” refers to owning cows and buffaloes only, whose dung are used to make solid fuels. OBC refers to Other Backward Classes. SC/ST refers to Scheduled Caste / Scheduled Tribe.

Summary statistics for households in the quantitative and qualitative data are shown in Table 3. 72% of households in the quantitative sample had an LPG stove, and all households (by construction) had an LPG stove in the qualitative sample. In both samples, gas use is remarkably low. If used regularly, one LPG cylinder would be expected to last a household with five members about one month (Dabadge, 2018). Based on this assumption, a household would be expected to use 0.20 LPG cylinders per month per person. The statistics in this table show that average gas use in these samples is about half of what it would be expected to be with regular use. Despite all of the households in the qualitative sample owning an LPG

stove, gas use in the qualitative sample is actually slightly lower than in the quantitative sample. This may be because the measure of use in the qualitative data accounts for the time it takes to use up the gas in a cylinder and the time it takes to get an empty cylinder refilled. The measure of use from the quantitative data, however, only accounts for the former. Because half of the households in the qualitative data were sampled from agency lists of households who had recently refilled a cylinder, and LPG use is correlated with economic status, the qualitative sample owns more assets on average than the quantitative sample. On other characteristics, the samples are relatively similar.

Figure 3: Asset wealth is positively associated with exclusive LPG use



The solid black line shows the average number of LPG cylinders per month per person in the household, by asset wealth. Estimates are based on the answer to the question: About how much time does one cylinder last in your household? Households that do not own an LPG stove are assigned a value of zero. Asset wealth is measured as a simple sum of six assets, including television, fan, mixer, pressure cooker, motorcycle, and refrigerator. A household of five members that regularly uses gas is expected to use one LPG cylinder per month, and therefore, 0.2 cylinders per month per person. Expected cylinders per month per person among regular gas users is shown as the red dotted line in the figure. Estimates use sample weights. Source: Survey of Rural Sanitation and Fuel Use.

Figure 3 shows average LPG use at different asset levels, using data from the quantitative survey. The upward slope of the line indicates that higher economic status is associated with an increase in the use of gas, but notably, even the richest households used about half as much gas as they would have been expected to if they had used it regularly. Why is the use of LPG so low in rural north India? The next section addresses this question.

5 Understanding the persistence of solid fuels

A skillful housewife preserves resources. Palriwala (1993) explains that a skillful housewife should preserve household resources and prioritize the good of the family over her own well-being. In coherence with this expectation, many of our respondents in the qualitative survey expressed the desire to preserve gas so that the household would not have to spend money to refill the cylinder often. This is despite the fact that 81% of women in the quantitative survey said that it is easier to cook on gas compared to the *chulha*.

The trade-off between what is easier for the cook and what is better for the household was discussed by several members of a Rajasthani joint family in which the two daughters-in-law of the household head preferred to cook on gas. The family lived in a multi-room brick house and was relatively well off. The household had two gas connections, one that it had bought on its own and one that it had gotten through Ujjwala, yet more than three months had elapsed between the past two cylinder refills. The younger son of the household head explained why using solid fuels was difficult:

For the *chulha*, you have to bring wood, and in the morning the wood does not catch fire quickly. On that [the gas stove] you just have to turn on the regulator switch and it catches fire. You have to put wood in the *chulha* and that's why it's troublesome.

The man's mother interjected here and said, "The *chulha* causes a lot of problems for young women." Nevertheless, as the most senior woman in the household, responsible for delegating household tasks to her daughters-in-law and controlling the household stocks, she wanted her daughters-in-law to cook on *chulha* to save money. She said:

If you use less of it [gas] then it will last longer. If it's used up quickly then where will the money come from? Brother, that's why. If you use it less then you spend less money.

Many of our respondents, both rich and poor, echoed this sentiment. Spending money to refill the cylinder was not seen as a priority. Even when women expressed a preference to

use gas more often, they often cited expenses related to educating their children, medicines, and replenishing household food stocks, as taking precedent over refilling the cylinder. Refilling the cylinder was in most cases not a decision that the cook could take herself; most respondents told us that it was the household head's decision. Regardless, women's stated prioritization of expenses which benefited other household members is in accordance with Palriwala (1993)'s description of a skillful wife's duty.

Gas use and women's laziness. In the context of trade-offs between preferences of the cook versus the well-being of the household as a whole, and general attitudes towards women's work as described by Jeffery, Jeffery and Lyon (1989), women who are seen as cooking on gas without good reason are considered lazy. Several men working in a gas distribution office in Rajasthan explained: "Women are lazy to go get wood, that's why they use gas...Older people fight for getting *roti* made on the *chulha*. There is a difference of opinion." These young men implied that using gas challenged traditional domestic hierarchies. Considering a daughter-in-law's status in rural north India, and the behavior that Mandelbaum (1988) and Jeffery, Jeffery and Lyon (1989) describe would be expected of her, disobeying one's elders in this way would be inappropriate and would be deserving of punishment.

A woman in Madhya Pradesh who lived with her four daughters, used similar language. Her husband had migrated to a large city five hours away for work, leaving our respondent and her daughters in the village. Because her husband was away from home so often, and because she did not live in a joint household with her parents-in-law, our respondent had substantial decision-making authority within the household. She told us:

We feel lazy. It is a big headache to light the *chulha*. That's why we don't cook on the *chulha*. We cook on gas. Now it's habit [to cook on gas]. If we're in a bind [if we've run out of gas], then we have to cook on *chulha*. Ladies these days have become lazy.

She and her daughters laughed. Based on the past two refills, and the number of regular members of her household, her use of gas was about half of what would have been expected of a family that regularly used gas. Even though she had likely used the word "lazy" ironically, her framing of cooking fuel decisions in those terms suggests that the spectrum on which rural north Indians evaluate the work of cooking is one of diligence versus laziness.¹²

¹²The interested reader might wonder why the respondent initially said that she "cook[s] on gas" when her answers to questions about refills suggest that she also substantially uses solid fuels. She certainly used gas more than many of her neighbors, who hardly used it at all. One reason for this could have been because neither she nor her daughters would collect wood. Using more gas meant that her husband would not have needed to collect as much wood when he was home. See Section 6 for a greater discussion of the reasons to use LPG.

Nevertheless, the association of laziness with using gas coheres with Jeffery, Jeffery and Lyon (1989)’s description of how women’s work is undervalued and belittled.

Gender, agricultural work, and using the *chulha*. In rural north India, households often use dung cakes, wood, and agricultural residue as solid fuels for cooking. Therefore, animal husbandry and farming facilitate the continued use of the *chulha* because they produce waste that can be used as solid fuels. In Figure 4, we present evidence from the quantitative data in support of this argument. The figure shows coefficients from a regression of gas use (measured as cylinders per month per person) on having animals, shown on the left side of the figure, and on cultivating land, on the right side.¹³ These regressions also control for asset wealth. The fact that the coefficients on owning at least one animal and cultivating land are negative and statistically different from zero signify that households practicing animal husbandry and farming were less likely to use gas.

On average, households that own animals and cultivate land are richer than households who do not. That these households are less likely to use LPG despite being richer suggests that gender is an important part of this story. Animal husbandry is one of the only kinds of economic activities in which women may acceptably engage. This contributes to the use of the *chulha* because it prevents women from becoming involved in other types of work that may be more profitable, and may increase the opportunity cost of their time. In our qualitative sample, only six of 45 cooks did other types of work for pay, a low proportion that illustrates the rejection of wage work in this context.¹⁴ On average, compared to the sample as a whole, the women that engaged in wage labor were more likely to be from poorer households that did not practice agriculture, and they were also slightly more likely to use gas.¹⁵ Compared to north India, patriarchal norms are less stringent in south India. Consistent with the explanation that rigid gender attitudes promote animal husbandry and encourage the use of solid fuels, compared to rural north India, a much smaller fraction of households in rural south India own cows and buffaloes, a larger fraction participate in wage labor, and a larger fraction use gas.¹⁶

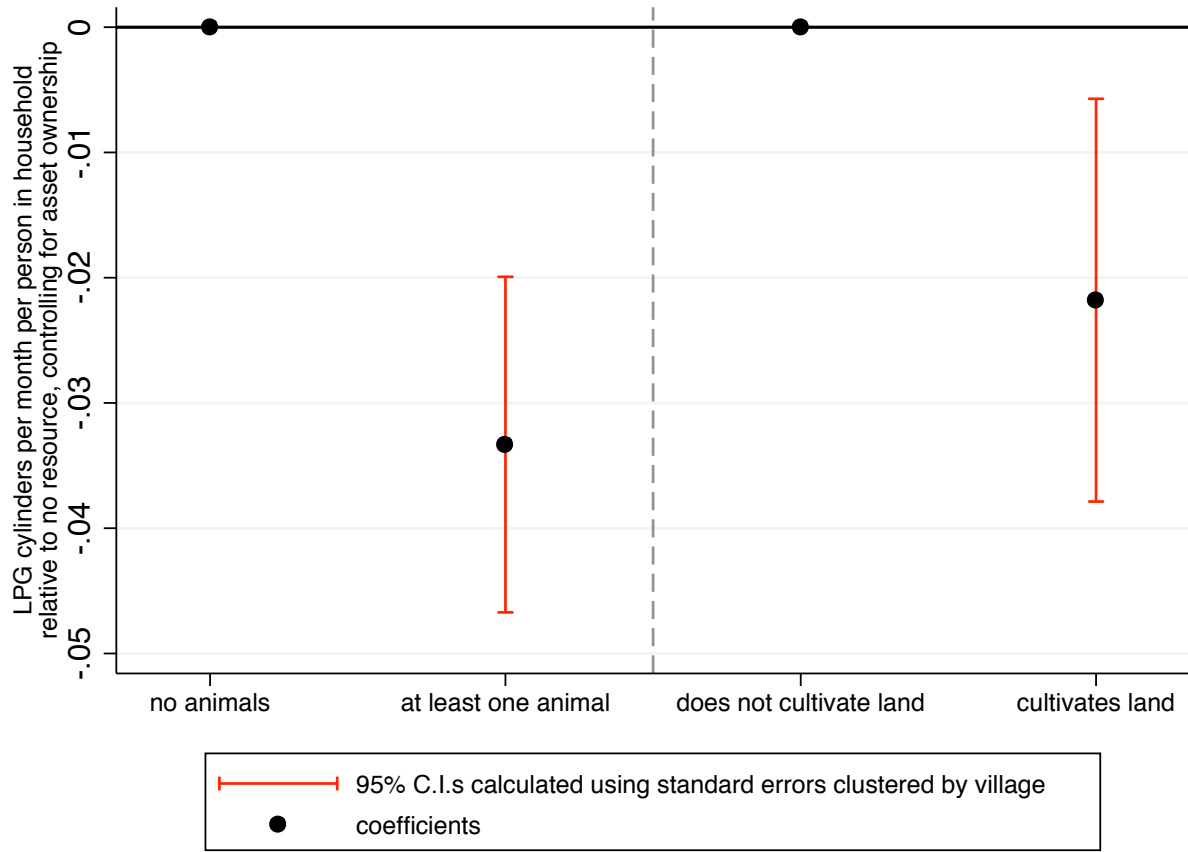
¹³Owning animals indicates ownership of cows or buffaloes, and also ownership of smaller animals such as goats. Dung-cakes, however, can only be made from the dung of cows and buffaloes. Unfortunately, the quantitative survey did not differentiate between different types of animals. We use data from the NFHS to ensure that the main result of this figure holds. Figure A1 shows the fraction of rural households in the NFHS using clean fuels at different levels of asset wealth, for households that own cows and buffaloes and those that do not, separately. The fact that the line for households that own cows and buffaloes is lower than the line for households that do not, at every level of asset wealth, supports the findings in the RSFU.

¹⁴The type of work included unskilled manual labor, cooking in government schools, sewing, or child-care work in an *anganwadi*.

¹⁵Four of the six cooks who worked for pay mentioned time-saving as an important reason for using gas instead of the *chulha*.

¹⁶Actual figures from India’s NFHS can be seen in Table 1. These facts do not, of course, provide causal evidence, but they are consistent with the idea that the more patriarchal norms in north India, compared to

Figure 4: Access to solid fuels is negatively associated with LPG use



The figure shows coefficients from two separate regressions of the number of LPG cylinders per month per person in the household, on having animals, shown on the left hand side, and on cultivating land, shown on the right hand side. The regressions also control for asset wealth. Not having the resource is the omitted category in both regressions. Estimates of LPG use are based on the answer to the question: About how much time does one cylinder last in your household? Households that do not own an LPG stove are assigned a value of zero. Estimates use sample weights. 95 percent confidence intervals use errors clustered by village. Source: Survey of Rural Sanitation and Fuel Use.

Much of the work related to preparing solid fuels also falls on women. It is almost exclusively women who make dung cakes, and both men and women cut and collect wood (Sharma, 2018; Anonymized, 2019a). In our qualitative work, we found the involvement of men in the work of cutting and collecting wood to be related to norms of modesty and seclusion for women. Cutting and collecting wood requires leaving the home, which would not be permitted of women who observe seclusion. In practice, the women who did participate in cutting and collecting wood were older, and by virtue of age and seniority in the household, south India, encourage agricultural work and the use of solid fuels for cooking.

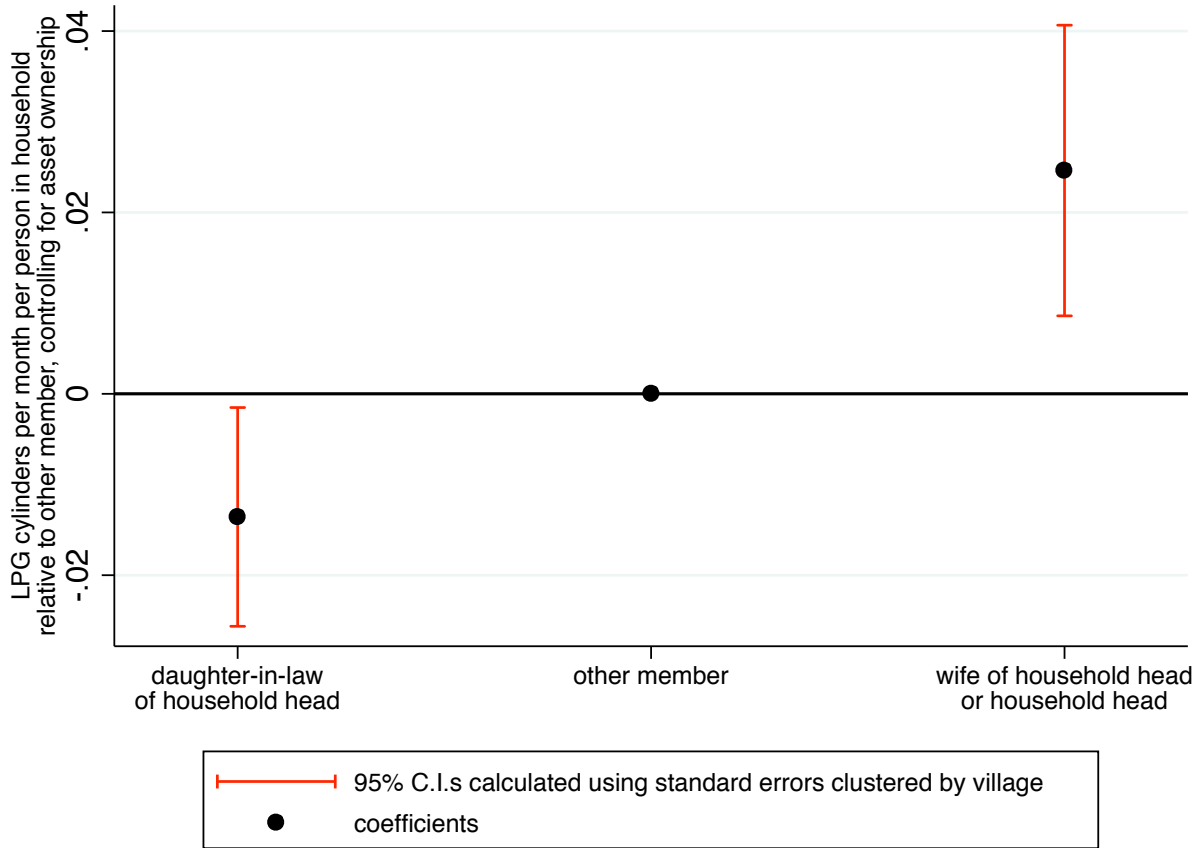
did not face the same expectations of modesty and seclusion as younger women.

Women’s status, intra-household communication, and LPG refills. Although cooking is women’s work, getting an LPG cylinder refilled is considered to be men’s work. Mandelbaum (1988) and Jeffery, Jeffery and Lyon (1989) describe that in a joint family household in rural north India, a daughter-in-law, who is often the cook, is expected to behave with respect and deference before her father-in-law and her husband’s elder brothers, who would decide when to refill the cylinder. This household hierarchy imposes constraints on communication between a daughter-in-law and the decision-maker and can slow the process of getting an LPG refill. A cook who is the wife of the decision-maker, on the other hand, does not face the same constraints.

Figure 5 presents evidence from the quantitative data supporting this argument. It shows coefficients from a single regression of gas use (the number of LPG cylinders per month per person) on the main cook’s relationship to the household head. The estimate on the left represents households in which the main cook was the household head’s daughter-in-law, a position of lower status. The estimate on the right represents households in which the main cook was the wife of the household head or was the household head, positions of relatively higher status. The estimate in the middle, which is also the omitted category in the regression, represents households in which the main cook had some other relationship to the household head, for example daughter or mother of the household head. This regression also controls for ownership of six assets. The results show that households in which the main cook was the daughter-in-law used statistically significantly less gas compared to cooks who were related to the household head in other ways, and households in which the main cook was the wife of the household head, or the household head, used statistically significantly more gas. Although this figure shows that higher status women used comparatively more gas, it is important to remember that even in these households, levels of gas use were still much lower, on average, than what would have been expected if gas were used all the time. Nevertheless, the presence of a gradient based on the intra-household status of the cook supports the role of women’s status in cooking fuel practices.

In our qualitative interviews, we asked respondents to describe the last time they refilled the cylinder. We found that low intra-household status often prevented cooks from communicating the need for an LPG refill. We spoke to the wife of the second son in a joint family household with three sons in Bihar. She was the youngest daughter-in-law (the youngest son was still unmarried), and was the main cook. The last time the gas cylinder became empty, she had to wait over a month before her in-laws decided to get it refilled. Our respondent told us, “I want [the cylinder] to be refilled quickly, but the guardian [father-in-law], if he has money then he will refill it.” We asked her if she had told her father-in-law that she

Figure 5: The main cook's intra-household rank is associated with LPG use



The figure shows coefficients from a single regression of the number of LPG cylinders per month per person in the household, on the main cook's relationship to the household head, which is indicative of status within the household. The regression also controls for asset wealth. Estimates of LPG use are based on the answer to the question: About how much time does one cylinder last in your household? Households that do not own an LPG stove are assigned a value of zero. The estimate on the left represents households in which the main cook is the household head's daughter-in-law, a position with low status. The estimate on the right represents households in which the main cook is herself the household head ($n=40$) or the wife of the household head ($n=476$) and thus has higher status. The estimate in the middle, which is the omitted category in the regression, represents households in which the main cook is some other household member. Estimates use sample weights. 95 percent confidence intervals use errors clustered by village. Source: Survey of Rural Sanitation and Fuel Use.

would like for it to be refilled quickly, and she responded, "I did not tell him to refill the cylinder quickly. I want it to be refilled quickly, that will be good. I did not tell him to refill it quickly." It would have been considered inappropriate for our respondent to try to advocate for a more rapid refill to her father-in-law.

We heard a similar story from the joint household in Rajasthan mentioned earlier. The two daughters-in-law also had to wait one month for the cylinder to be refilled. They were

having difficulty lighting the *chulha* in the morning because it was winter and the wood was wet from the fog and cold. Even though their father-in-law was the one who made the refill decision, it was their mother-in-law whom they told about their trouble. The mother-in-law eventually told her husband to get the refill, but only when she thought it was the right time.¹⁷ These types of intra-household communication barriers are similar to those identified by Das Gupta (1995) in the context of maternal and child health.

Positive attitudes towards food cooked on *chulha*. In the quantitative survey, 92% of women said that food cooked on the *chulha* is tastier and 86% said it is healthier than food cooked on gas. In the qualitative survey, we found that these beliefs were widespread among both educated and uneducated respondents, and among those that used gas often and rarely.

A young woman in Madhya Pradesh who was in her first year of a Master of Science in Mathematics explained why food cooked on a *chulha* is healthier:

According to me, the wood, the food cooked on wood is better for health. Like the protein, the vitamins, the calcium that is there [in the food], it is more digestible [when cooked] on wood. On gas, the food is different.

Many respondents also told us that eating food cooked on gas causes gas. An elderly woman who lived with her husband in Bihar, and who had to regularly use gas because she and her husband walked with difficulty, told us:

Eating food cooked on gas makes people obese. Haven't you seen this in cities? They are filled with air. People of that side [cities], they become swollen, [but their] bones lack strength. [If] a thin person pushes the obese person, he will fall down. The thin person has [more] strength.

Over and over, our respondents shared strong positive attitudes related to taste and health towards food cooked on a *chulha*. These positive attitudes towards food cooked on the *chulha* contribute to a culture that promotes the use of solid fuels for cooking. Women in rural north India are cooking in a context which highly favors the *chulha*.

¹⁷It is likely that the father-in-law would have known of the problems posed by the damp wood, because breakfast would have taken longer to cook, and there would have been more smoke coming from the *chulha*. However, he did not get it refilled until his wife asked him to. Young women's low status, therefore, may not only hinder communication between the cook and the decision-maker, it may also prevent the development of a cooperative relationship with the decision-maker. This would produce the same pattern that we observe here: greater use of gas among cooks who have a closer relationship with the decision-maker, such as wife compared to daughter-in-law.

6 Understanding the use of clean fuels

We have shown various ways in which gender attitudes related to women's status, seclusion, and work discourage the use of gas in rural north India. It is common for households that have an LPG stove to use gas some of the time, for instance to make *chai* so that it can be served quickly to a guest. We repeatedly heard respondents say they sometimes used both gas and *chulha* when they were running late and needed to prepare food quickly. Respondents also told us that they used gas when it was raining or if the solid fuels were wet. Although not mentioned by respondents, it may also be the case that it is economical to cook small things, such as *chai*, on gas, because some amount of solid fuel would continue burning as the *chulha* cools down after the *chai* has been cooked. For these households, gas was valuable because it was convenient in these exceptional circumstances. However, the norm was to use the *chulha*. Some households, though, regularly used gas, and gender norms play an important role in explaining these households' cooking practices as well.

In the typical rural north Indian household, agriculture facilitates the production of solid fuels. Women make dung cakes from the dung of their cows and buffaloes, older women and men cut and collect wood, and a daughter-in-law cooks. The households that we observed using gas more often differed in important ways from this description of the typical household. Some households did not practice animal husbandry, and gender norms relating to seclusion and *purdah* made it difficult for women to collect solid fuels. If there were no men or elder women to collect wood, many of these households resorted to using gas. Another reason to use gas was age and disability. Elderly men and women whose sons and daughters-in-law lived separately were also likely to use gas because collecting solid fuels and cooking on the *chulha* were difficult.

Gender and work in non-agricultural or semi-agricultural households. In Section 5, we explained that agriculture and gender norms supporting women's involvement in animal husbandry promoted the use of solid fuels for cooking. Here, we describe how cooking fuel decisions were made among households that did not farm, or did not own animals. Because these households did not have animals that produced dung or land that produced agricultural residue, they had to rely on buying dung cakes, using the dung of their neighbors' cows, or collecting or buying wood. These resources were not always available. When they were, norms promoting women's seclusion sometimes prevented women from going to get them.

A woman who lived with her two children in Bihar while her husband worked in Delhi explained that she initially bought a gas connection in 2013 because of the difficulty in finding solid fuels. Her household cultivated land, but she did not own cows or buffaloes,

and she used gas to cook almost everything when she had gas in her cylinder. She said:

At that time, solid fuels weren't available anywhere. Other people sell dung cakes, they make them and sell them. We went to them [to buy dung cakes] and they said that they are keeping them [the dung cakes] for themselves. After that, out of necessity, we had to buy it [a cylinder].

Even though this respondent's household had separated from the joint family, her husband's brothers and their families lived in the same compound. In this setting, it was important for her to practice modesty and seclusion, and she did not leave the home to acquire solid fuels. She would ask her children to buy dung cakes from the market, and her husband would collect wood when he visited. In fact, when her LPG cylinder recently became empty, her husband told her on the phone from Delhi to get it refilled quickly. Recounting the conversation with her husband, she told us: "My husband told me to refill it quickly because where would I go to get solid fuels?" She decided to wait to get it refilled because she had some wood and dung cakes at home, and she needed to pay some agricultural laborers for the work they had done on her farm first. A week later, when she had received more money from her husband, she got the cylinder refilled.

As the prior example demonstrated, cooks who follow norms of seclusion in households that do not own animals must rely on other members of their family to bring solid fuels. In joint families, mothers-in-law, fathers-in-law, and husbands of the cook often do this work. However, if the household has separated from the joint family, the cook may have to rely on her husband and children, or may have no one to rely on at all. Another respondent from Bihar had no one to bring solid fuels, and she used gas exclusively. Her husband lived in the district capital two hours away and her children were too young to collect wood for her. She was from the Rajput caste and vigorously practiced seclusion. Her niece, who lived next door, also participated in the interview and contrasted her aunt's solid fuel situation and cooking practices to those in her own household. She said:

The main thing is that my uncle [the main respondent's husband] is not here. So where will the solid fuels come from? In my house these people are here [the niece's brothers] so they bring all that [solid fuels], so gas use is less and *chulha* is more. For her [the respondent], gas use is more and *chulha* less. That is the thing.

Because of stringent expectations regarding seclusion that prevented her from leaving the home to collect solid fuels, and the fact that the respondent's husband had migrated for work, this respondent used gas.

For women who are constrained by practices of seclusion, buying solid fuels is also an option. However, this may not be an economically attractive option. The monthly cost of LPG is similar to what Anonymized (2019a) have found to be the average monthly cost of solid fuels among households who purchased them.

Age, disability, and the use of solid fuels. Another reason to regularly use gas is because of disability or age. We spoke to several elderly respondents and couples who lived on their own. They used gas more often because preparing solid fuels and cooking on the *chulha* was difficult. Many, however, preferred food cooked on the *chulha*. A poor widow who lived alone in Madhya Pradesh used gas most of the time because her hand hurt and collecting wood was physically difficult for her. However, she would have preferred to eat food cooked on the *chulha*. She said:

The food cooked on the wood *chulha*, it is flavorful, and the food cooked on gas is not. There is a big difference with food cooked on gas. The food cooked on *chulha*, that we always eat, it is [flavorful]. I'll tell you how it is in the countryside. We have a jungle here. It has wood, so the food cooked on wood is made tasty, and the food cooked on [gas] is not as tasty. But now I have to eat it [food cooked on gas]. Brother, who will bring it [wood]? I've been compelled [to use gas].

Another elderly couple we spoke to in Bihar also used gas because of disability. They lived in one room on the roof of their son's plastered brick home, but they cooked separately from their son's family. The woman had poor eye sight, and walked with difficulty. Her husband was also in poor health; he joined us in the middle of the interview and had to lay down for several minutes after walking up the stairs. Collecting or making solid fuels would have been very burdensome for this couple. They did pay someone to cut and bring wood occasionally, but our respondent mostly cooked on gas because it was easier than setting fire to the wood and using the *chulha*. This couple also expressed a preference for food cooked on the *chulha*, though.

Among the elderly couples that regularly used gas, many stated a preference for eating food cooked on the *chulha*. Had these couples been living jointly with their children, they would have likely urged greater use of the *chulha*. Considering household hierarchies, a daughter-in-law would have been unable to go against the wishes of her parents-in-law, and it is likely that she would have been expected to use solid fuels more regularly than the elderly couples were able to on their own.

7 Discussion

This paper adds to the literature on the use of clean cooking fuels by studying a unique policy environment that dramatically expanded LPG access. Using novel quantitative and qualitative data from rural north India, we shed light on how gender norms and attitudes related to women’s status, women’s seclusion, and women’s work contribute to the persistence of solid fuels in rural north India. We document that social forces, and in particular north India’s patriarchal norms and attitudes, encourage women to preserve gas, promote women’s work that facilitates the use of solid fuels, and hinder communication between the cook and the decision-maker regarding LPG refills. This research has important implications for both policy and research.

Implications for policy. Our findings highlight the importance of focusing on clean fuel *use* rather than infrastructure in India. The Ujjwala Yojana has dramatically increased LPG ownership. This is a notable achievement. Our findings suggest, however, that this program did not produce a large-scale change in cooking practices in rural north India. Given that even the wealthiest households in the region use gas about half the time, India’s clean energy policy would likely be more successful if it addressed the underlying social environment in which cooking fuel decisions take place.

Another important aspect of India’s clean energy policy is that it subsidizes LPG refills. Theoretically, the subsidy is well-targeted because it incentivizes LPG use. However, the evidence that so few household in rural north India regularly use gas suggests that the subsidies are not high enough to generate a meaningful change in behavior. It is unclear what impact an increase in subsidies would have on LPG use. Our findings suggest that moderate changes in the subsidy may not have large effects given the little value placed on women’s labor, and the constraints on women’s engagement in paid work. Patriarchal norms and attitudes make the opportunity cost of women’s labor very low. Therefore, the cost of gas might also need to be very low in order to substantially change household cooking behaviors.

How might policy address the social barriers to LPG use? That gender norms and attitudes are an important part of cooking fuel decisions is not lost on the Indian government. Indeed, advertisements for Ujjwala emphasize its benefits for women. It is certainly true that LPG is beneficial for women, but within the context of north Indian patriarchal norms and attitudes, these advertisements further reinforce women’s roles as cooks. From the perspective of a rural north Indian decision-maker who underestimates women’s work, and neglects women’s well-being, our research suggests that advertisements such as these do not present a particularly convincing argument to buy LPG. Since men are the decision-makers,

framing LPG use as beneficial for men is a potentially useful avenue to explore. More broadly, policies and campaigns that challenge gender norms within north Indian households may improve LPG use.

Implications for research. The findings of this research also push forward the clean energy research agenda. We identify the underlying mechanisms that drive the cross-sectional correlations between gender indicators and clean fuel use discussed in the literature (Kishore and Spears, 2014; Gould and Urpelainen, 2019; Choudhuri and Desai, 2020). Although researchers have long recognized the importance of gender in research on fuel use (Parikh, Smith and Laxmi, 1999; Wickramasinghe, 2003), we clarify and discuss in detail all of the ways in which north Indian gender attitudes and norms promote the use of solid fuels, and explain the little regular gas use that exists. An open question is the extent to which these issues are salient in other parts of India. Available evidence suggests that gender norms in South India are not as constrained (Kapadia, 1995), and the transition to LPG is much quicker (Alexander and Padmanabhan, 2020).

An important avenue for future research is to explore potential interventions that generate meaningful changes in cooking practices. Pillarisetti et al. (2019) report on a pilot study testing various interventions aimed at addressing barriers to LPG use in rural India. There is great need for more such studies. Further research in this area should be attentive to patriarchal norms and attitudes that encourage solid fuel use in north India.

A final contribution is methodological. Moving forward, research in India should focus on LPG use, but how should use be measured? In this study, we propose an effective measure of LPG use: LPG refills per month per person. This measurement can be easily collected in a household survey that contains a household roster, by either looking at a household's LPG booklet to see the dates of the past few refills, or by asking the household to report on when or how often it has refilled the cylinder. This measure may also be available from administrative data (Kar et al., 2019), which should ideally be linked to household characteristics to understand barriers to LPG use (Afridi, Debnath and Somanathan, 2020).

The decline in joint household structures, higher incomes, and the increase in migrant work among males may over time allow more women in rural north India to transition to LPG for cooking. In the meantime, however, the use of solid fuels poses a major threat to the health of rural north Indians, and particularly to the health and human capital accumulation of children. Accelerating the transition to clean fuels is an important policy priority. Future research and policy should take seriously the gender norms and attitudes that currently discourage the use of LPG.

References

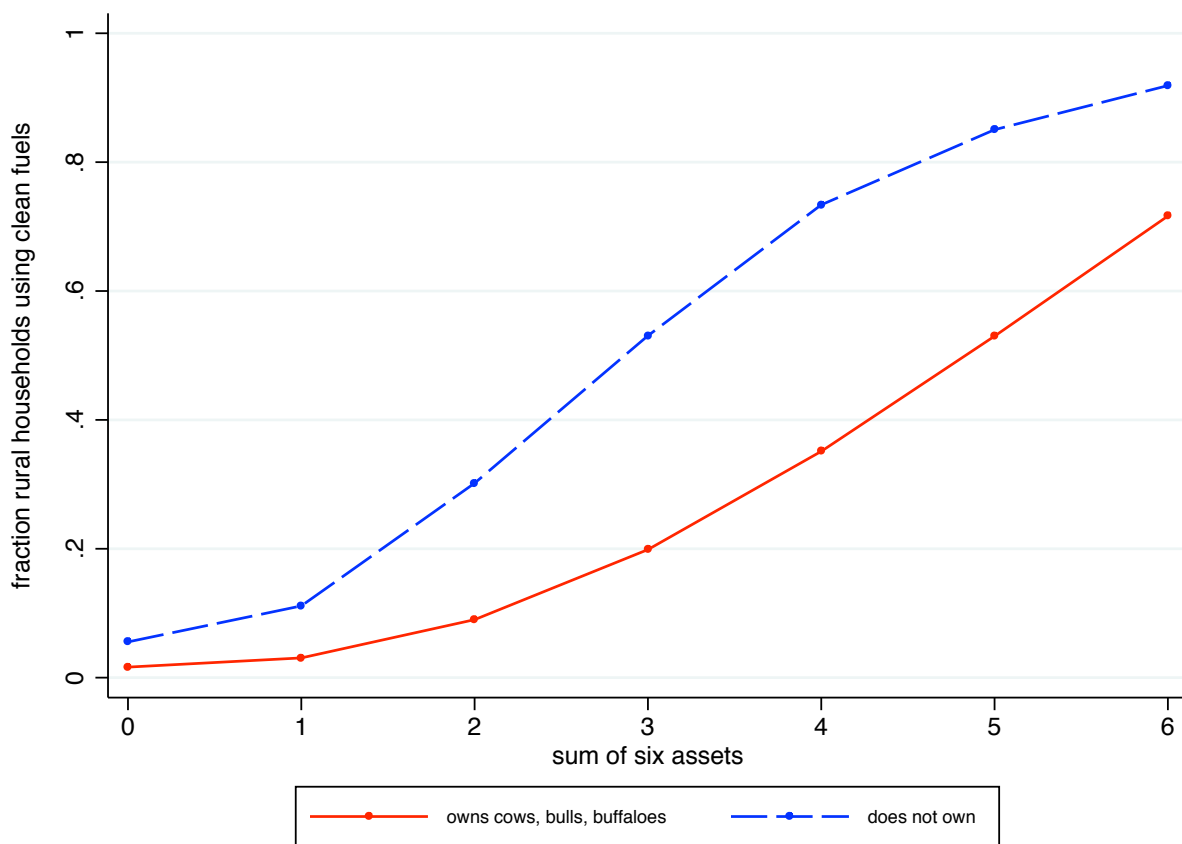
- Afridi, Farzana, Sisir Debnath, and E. Somanathan. 2020. “A Breath of Fresh Air: Raising Awareness for Clean Fuel Adoption.” *working paper*.
- Afridi, Farzana, Taryn Dinkelman, and Kanika Mahajan. 2016. “Why are fewer married women joining the work force in india? a decomposition analysis over two decades.”
- Alexander, Sneha, and Vishnu Padmanabhan. 2020. “The PMUY’s cooking gas refill issue.” *LiveMint*.
- Anonymized, A. 2014.
- Anonymized, B. 2019*a*.
- Anonymized, C. 2019*b*.
- Anonymized, D. 2019*c*.
- Banerji, Rukmini, Suman Bhattacharjea, and Wilima Wadhwa. 2013. “The annual status of education report (ASER).” *Research in Comparative and International Education*, 8(3): 387–396.
- Behera, Bhagirath, Aryal Jeetendra, Akhter Ali, et al. 2015. “Household collection and use of biomass energy sources in South Asia.” *Energy*, 85: 468–480.
- Caldwell, John C. 1986. “Routes to low mortality in poor countries.” *Population and development review*, 171–220.
- Cheng, Chao-yo, and Johannes Urpelainen. 2014. “Fuel stacking in India: Changes in the cooking and lighting mix, 1987–2010.” *Energy*, 76: 306–317.
- Choudhuri, Pallavi, and Sonalde Desai. 2020. “Gender inequalities and household fuel choice in India.” *Journal of Cleaner Production*, 121487.
- Coffey, Diane, and Dean Spears. 2019. “Neonatal death in India: birth order in a context of maternal undernutrition.”
- Coffey, Diane, Payal Hathi, Nidhi Khurana, and Amit Thorat. 2018. “Explicit Prejudice.” *Economic & Political Weekly*, 53(1): 47.
- Dabadge, Ashwini. 2018. “What has the Pradhan Mantri Ujjwala Yojana achieved so far?” *Economic and Political Weekly*.
- Das Gupta, Monica. 1995. “Life course perspectives on women’s autonomy and health outcomes.” *American Anthropologist*, 97(3): 481–491.
- Das, Sukanya, Hugo De Groote, Bhagirath Behera, et al. 2014. “Determinants of household energy use in Bhutan.” *Energy*, 69: 661–672.

- Desai, Sonalde, et al.** 1994. "Gender inequalities and demographic behavior." *India, New York*, 16.
- Dyson, Tim, and Mick Moore.** 1983. "On kinship structure, female autonomy, and demographic behavior in India." *Population and development review*, 35–60.
- Gould, Carlos F, and Johannes Urpelainen.** 2018. "LPG as a clean cooking fuel: Adoption, use, and impact in rural India." *Energy Policy*, 122: 395–408.
- Gould, Carlos F, and Johannes Urpelainen.** 2019. "The Gendered Nature of Liquefied Petroleum Gas Stove Adoption and Use in Rural India." *The Journal of Development Studies*, 1–21.
- Hennink, Monique M, Bonnie N Kaiser, and Vincent C Marconi.** 2017. "Code saturation versus meaning saturation: how many interviews are enough?" *Qualitative health research*, 27(4): 591–608.
- Hirway, Indira, and Sunny Jose.** 2011. "Understanding women's work using time-use statistics: The case of India." *Feminist Economics*, 17(4): 67–92.
- Jain, Abhishek, Saurabh Tripathi, Sunil Mani, Sasmita Patnaik, Tauseef Shahidi, and Karthik Ganesan.** 2018. "Access to clean cooking energy and electricity: Survey of states 2018." *CEEW Report, Council on Energy, Environment and Water (CEEW), New Delhi, India*.
- Jeffery, Patricia, Roger Jeffery, and Andrew Lyon.** 1989. "Labour pains and labour power: Women and childbearing in India."
- Jejeebhoy, Shireen J, and Zeba A Sathar.** 2001. "Women's autonomy in India and Pakistan: the influence of religion and region." *Population and development review*, 27(4): 687–712.
- Kapadia, Karin.** 1995. "Siva and Her Sisters: Gender, Caste, and Class in Rural South India. Boulder." *CO: Westview*.
- Kar, Abhishek, Shonali Pachauri, Rob Bailis, and Hisham Zerriffi.** 2019. "Using sales data to assess cooking gas adoption and the impact of India's Ujjwala programme in rural Karnataka." *Nature Energy*, 4(9): 806–814.
- Kishore, Avinash, and Dean Spears.** 2014. "Having a son promotes clean cooking fuel use in urban India: Women's status and son preference." *Economic Development and Cultural Change*, 62(4): 673–699.
- Mandelbaum, David G.** 1988. *Women's seclusion and men's honor: Sex roles in North India, Bangladesh, and Pakistan*. University of Arizona Press.
- Masera, Omar R, Barbara D Saatkamp, and Daniel M Kammen.** 2000. "From linear fuel switching to multiple cooking strategies: a critique and alternative to the energy ladder model." *World development*, 28(12): 2083–2103.

- Mottaleb, Khondoker Abdul, Akhter Ali, et al.** 2017. “An exploration into the household energy choice and expenditure in Bangladesh.” *Energy*, 135: 767–776.
- Palriwala, Rajni.** 1993. “Economics and patriliney: Consumption and authority within the household.” *Social scientist*, 47–73.
- Parikh, Jyoti, Kirk Smith, and Vijay Laxmi.** 1999. “Indoor air pollution: a reflection on gender bias.” *Economic and Political Weekly*, 539–544.
- Pillarisetti, Ajay, Makarand Ghorpade, Sathish Madhav, Arun Dhongade, Sudipto Roy, Kalpana Balakrishnan, Sambandam Sankar, Rutuja Patil, David I Levine, Sanjay Juvekar, et al.** 2019. “Promoting LPG usage during pregnancy: A pilot study in rural Maharashtra, India.” *Environment international*, 127: 540–549.
- Rahman, Lupin, and Vijayendra Rao.** 2004. “The determinants of gender equity in India: examining Dyson and Moore’s thesis with new data.” *Population and Development Review*, 30(2): 239–268.
- Salvi, Sundeep S, and Peter J Barnes.** 2009. “Chronic obstructive pulmonary disease in non-smokers.” *The lancet*, 374(9691): 733–743.
- Sen, Amartya.** 2003. “Missing women—revisited.”
- Sharma, Kanika.** 2018. “Living with pain: women’s everyday lives and health in rural Bihar.” *The Hindu Centre for Public Policy*.
- Smith, Kirk R.** 2000. “National burden of disease in India from indoor air pollution.” *Proceedings of the National Academy of Sciences*, 97(24): 13286–13293.
- Srinivas, Mysore Narasimhachar.** 1977. “The changing position of Indian women.” *Man*, 221–238.
- Wickramasinghe, Anoja.** 2003. “Gender and health issues in the biomass energy cycle: impediments to sustainable development.” *Energy for Sustainable Development*, 7(3): 51–61.
- Wilkinson, Paul, Kirk R Smith, Michael Davies, Heather Adair, Ben G Armstrong, Mark Barrett, Nigel Bruce, Andy Haines, Ian Hamilton, Tadj Oreszczyn, et al.** 2009. “Public health benefits of strategies to reduce greenhouse-gas emissions: household energy.” *The Lancet*, 374(9705): 1917–1929.
- World Health Organization.** 2016. “Burning Opportunity: Clean Household Energy for Health, Sustainable Development, and Wellbeing of Women and Children.”

Appendix

Figure A1: Lower rural clean fuel use among households that own cows and buffaloes compared to those that do not, at every level of asset wealth



Source: India's National Family Health Survey 2015-2016.