A Breath of Fresh Air: Raising Awareness for Clean Fuel Adoption *

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Abstract

Air pollution is amongst the gravest public health concerns worldwide and indoor sources are the largest contributors in many developing countries. Attempts to persuade households to use more efficient solid-fuel cooking stoves have been mostly unsuccessful in reducing air pollution. We build on a new, nation-wide program in India that has provided access to liquefied petroleum gas (LPG) for cooking to more than 70 million households but is yet to induce consistent use of LPG in place of polluting solid fuels. In our study in central India, we randomly assign villages to a campaign carried out by rural public health workers to inform households about the adverse health effects of inhaling smoke from solid fuels. In a second treatment arm, we combine health information with a break-down of the financial implications of the existing public subsidy to LPG consumers. We then analyze the take-up and usage of LPG (as well as other outcomes) by households in the health, and health plus subsidy awareness treatments relative to the control group of villages in which the campaign was not initiated. Our findings carry implications for public policy aimed at behavioral changes that can reduce air pollution.

Keywords: air pollution, solid fuels, LPG, health, subsidy, awareness, India
JEL Codes: D10, D90, I15, Q53

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1 Introduction

Air pollution levels in households that cook with solid fuels are high and skyrocket during meal preparations. Figure 1 shows PM2.5 levels during a typical day in a rural household, in northern India.[1] While the World Health Organization's guideline for 24-hour average exposure to this pollutant is $25\mu g/m^3$, it rises to as much as $1000\mu g/m^3$ during meal preparations in these households - 40 times greater than the safe limit. Not surprisingly, air pollution is one of the gravest public health concerns, not only in developing countries but across the world (Cohen *et al.*, 2017). Household sources, however, are the single largest contributor in much of the developing world (Liu *et al.*, 2016; GBD-MAPS, 2018). We implement a cluster-RCT in a rural area of India that aims to induce households to switch to a clean cooking fuel.

Our study builds on a novel program launched by the Government of India in 2016 to provide subsidized access to bottled liquid petroleum gas (LPG) to disadvantaged households. While the program has been a huge success, with more than 72 million households gaining access by June 2019, average annual usage of LPG by the existing and newly connected rural households remains less than half of what is thought to be needed to eliminate solid fuel use.[2] We design and implement a cluster-randomized controlled trial in a rural area of the state of Madhya Pradesh, that aims at increasing awareness about the health hazards of cooking with solid fuels. The intervention has two treatment arms: one in which awareness about the adverse health effects of cooking with solid fuels is provided to household members, and a second which, in addition to health awareness, explains the existing cashback payment deposited directly to consumers' bank accounts by the government after they purchase a refill of LPG at market price.

Our primary outcome is annual and seasonal LPG consumption by the households in our sample to assess whether improved awareness increases the uptake of LPG for cooking. In addition, we will measure several other outcomes such as acquisition of new LPG connections

[1] PM2.5 refers to atmospheric particulate matter (PM) that have a diameter of less than 2.5 micrometers. Major components of PM are sulfates, nitrates, ammonia, sodium chloride, black carbon, mineral dust, and water.

[2] More information can be found at http://www.pmujjwalayojana.com/.

among the roughly one-third of households that did not have connections at baseline, use of solid fuels, awareness of health hazards of solid-fuels, and various self-reported measures of health. A comparison of the estimated impacts between the two treatment arms allows us to assess complementarities between awareness of health benefits and awareness of the cost of a clean fuel.

One reason for the low usage of LPG, of course, is poverty in developing countries. Although LPG is subsidized in India, the cost can still be considerable for poor households. But in addition, and irrespective of income, there is low awareness of the long-term health hazards of solid fuel combustion - pre-term deaths and low birth weight of infants born to mothers who inhale smoke from solid fuels during pregnancy, as well as respiratory, cardiovascular and eye diseases.[3] Our baseline survey reveals that 87% of the sampled households are unaware of the serious long-term risks to their own or other household members' health. In addition to ignorance on adverse health effects, field visits and other anecdotal evidence suggests that many rural households are either unaware of the government's cash-back scheme on LPG purchases or do not understand the extent of the subsidy they receive on refills.

Cooking with solid fuels contributed to ambient air pollution in the now developed countries in the last century as exemplified by the infamous London fogs. The developed world cleaned up by switching to gas and electricity instead of coal and wood for cooking and heating (Freese, 2006). However, gas and electricity require considerable infrastructure as well as recurring expenditures by households. Both these requirements were thought to be too demanding for much of the developing world, especially the poorer countries of sub-Saharan Africa and South Asia. As a result, there have been many attempts to promote improved solid-fuel cookstoves starting

[3]WHO estimates that 3.8 million premature deaths were attributable to household air pollution in 2016, mostly in low and middle-income countries. Furthermore, according to the American Heart Association "exposure to PM2.5 over a few hours to weeks can trigger cardiovascular disease-related mortality and nonfatal events; longer-term exposure (e.g., a few years) increases the risk for cardiovascular mortality to an even greater extent than exposures over a few days and reduces life expectancy within more highly exposed segments of the population by several months to a few years." While PM10 particles can penetrate and lodge deep inside the lungs, PM2.5, being far smaller, can enter the blood system and contribute to the risk of developing respiratory diseases, including lung cancer, besides cardiovascular diseases.

in the 1970s and 1980s. These technologies have, by and large, failed to reduce household air pollution for a variety of reasons - they have low adoption rates (Venkataraman *et al.*, 2010), low usage rates when adopted (Hanna *et al.*, 2016; Sambandam *et al.*, 2015; Venkataraman *et al.*, 2010), and are not sufficiently effective even when used (Venkataraman *et al.*, 2010; Sambandam *et al.*, 2015). Our study, in contrast, emphasizes adoption and regular usage of a clean fuel for cooking.

The literature in economics on the effects of improving awareness about the health effects of pollution on the demand for pollution mitigation began with work on water quality and has shown mixed results. The earliest studies (Madajewicz *et al.*, 2007; Jalan and Somanathan, 2008) found substantial effects of information on mitigating behavior following the provision of personalized information to recipients. Madajewicz *et al.* (2007) show that in Bangladesh people who were unknowingly using arsenic contaminated wells (assumed to be randomly distributed) were more likely to switch to a safer source of water if the well was marked unsafe compared to people who were using an unmarked well. Jalan and Somanathan (2008) was a cluster RCT in an Indian city that provided test results of household water quality and found that it resulted in an increase in within-home water purification.

Subsequent research on this issue has also mostly been in the area of water and sanitation (Guiteras *et al.*, 2016; Bennett *et al.*, 2018; Davis *et al.*, 2011). Guiteras *et al.* (2016), however, find no impact of health information on household water chlorination and hand-washing in their RCT in slums in Bangladesh even when additional cues meant to trigger disgust and shame were added to the provision of information. Bennett *et al.* (2018) find effects on behavior and anthropometrics of hygiene information in an RCT in rural Pakistan only when visual details on bacteria were part of the informational package. Davis *et al.* (2011) in an RCT in peri-urban Tanzania show that information increased self-reports of hygiene behaviors but did not reduce contamination of stored water.

This is the first study to measure the extent to which awareness impacts mitigating behavior in the case of air pollution. It will have implications well beyond the current Indian program for provision of bottled gas because many developing governments in South Asia and Africa are expanding their electricity networks, bringing the possibility of electric cooking with now

cheap induction stoves to hundreds of millions of people. The extent to which these possibilities are realized could be influenced by what people know about the health hazards of indoor air pollution. Our second innovation is that our awareness campaign is embedded within the rural public health system. We hire existing frontline public health workers in villages to conduct a door-to-door campaign by making up to 6 household visits over a nine-month intervention period. These workers are incentivized financially in a manner and at a rate that is comparable to their existing remuneration. Our experimental intervention is, therefore, not just potentially scalable but is also replicable unlike many RCTs which are conducted by highly motivated research teams.

Our study contributes to multiple strands of research in economics. First, our experiment builds on existing literature on the role of information in inducing behavioral change. In our context, since individual behavior (i.e., fuel choice) generates externalities through a spillover effect on overall air quality, evaluating the potential of nudges in reducing environmental degradation carries even greater significance. Furthermore, self-reported outcomes could be biased by yea-saying, as may have been the case in Davis *et al.* (2011) but the extent of the bias is not clear. In our endline survey, we will collect self-reports of new LPG connections, and self-reports of cylinder refill purchases, and we will verify these information using sales data of the public oil marketing companies.

Our research will inform policy measures that can be taken to reduce households' use of polluting solid fuels. Moreover, since we will observe expenditure on LPG in response to the intervention, our findings can also speak to the growing literature on measuring households' willingness to pay for health and how much it depends on households awareness (Somanathan, 2010; Kremer *et al.*, 2011; Greenstone and Jack, 2015). Even though we do not directly measure the value of clean air to poor households, our study may be the first to offer some insight on the effect of health awareness about household air pollution on fuel choice and fuel expenditure in a country which had 22 of the world's 30 most air-polluted cities in 2018.[4]

[4]The 2018 ranking of world's most polluted cities by IQAir is available at https://www.airvisual.com/world-most-polluted-cities?continent=&country=&state=&page=1&perPage=50&cities=.

The remainder of the paper is organized as follows. In Section 2, we discuss the existing market for bottled LPG for cooking in India. In Section 3, we outline our sampling strategy, awareness campaign, and its implementation. A summary of the data from the baseline survey is presented in Section 3.3. We elaborate on our estimation methodology in Section 4. Section 5 offers some interpretation of potential results and Section 6 concludes.

2 Background

While supply-side constraints were a limiting factor in both urban and rural households' access and utilization of LPG for cooking in India in the past, access to LPG has gone up significantly due to an increase in spatial coverage of LPG distributors (PPAC Report, 2018), rising incomes, and the financial subsidy provided by the state.

To buy subsidized LPG, Indian consumers have to obtain a "connection" - register with one of the three state-owned oil marketing companies (OMCs) that are the only suppliers of LPG. A consumer has to pay a connection charge, a deposit for a cylinder and pressure regulator, and purchase a rubber pipe at any OMC's local distributor or "dealer". This is an upfront cost of about 3200 rupees (45 USD), which could easily be two weeks worth of household income in rural areas.[5] Since 2013 all residential LPG consumers in India, irrespective of income, receive a so-called 'direct benefit transfer' (DBT) for up to 12 cylinder refills in a year.[6] This

[5]"Connection" is the official term that refers to registration for obtaining the pressure regulator and consumer booklet along with the first cylinder. A connection entitles the consumer to the LPG subsidy. In order to register for a connection a consumer has to provide proof of identity and address and submit a security deposit of 25 USD. The security deposit is for the empty 14.2 kg capacity cylinder plus the pressure regulator. The consumer has to pay the market price separately for the gas in the cylinder (10 USD) and a stove (10 USD). The regulator does not come with the stove (which can be purchased by anyone on the market). It is given only by the LPG dealer, along with the cylinder, when the consumer obtains the connection. The pressure regulator has to be returned by the consumer (along with an empty cylinder) to recover the deposit. Note that the the average rural household income was approximately 7215 rupees (100 USD) per month in 2011, the latest year for which these estimates are available (Desai *et al.*, 2011).

[6]Throughout this document we refer to a cylinder with 14.2 kgs of LPG, the standard size

means that when a consumer with an LPG connection buys a cylinder of LPG, she pays the market price to the dealer and receives a transfer to her bank account for the amount of the subsidy to which she is entitled within the next 2-3 days. The market price of a cylinder varied between 654 and 879 rupees during November 2017 to October 2018 in tandem with the price of imported liquefied natural gas. The government has kept the subsidized price very stable at around 500 rupees so that the corresponding subsidy delivered by direct benefit transfer varied between 159 and 376 rupees during this period.[7]

In order to expand access to LPG the Government of India launched the Pradhan Mantri Ujjwala Yojana (PMUY) in April 2016.[8] The PMUY is the largest program on access to clean fuel in Indias history and the world, reaching 72 million poor families between April 2016 and June 2019. The program mandates that a woman in a rural, socio-economically disadvantaged household, obtaining an LPG connection (giving a right to buy subsidized gas) bears no upfront cost. The security deposit, along with administrative charges for a connection are borne by the government. The woman also receives an interest-free loan from the OMC for purchase of the stove and the gas in the first cylinder.[9] The program has positioned itself as an initiative

of a cylinder in the Indian market.

[7]All registered consumers are assigned a unique consumer number and a booklet that records, among other details, the date of LPG connection, LPG dealer, and purchase of every LPG refill. Consumers can purchase refills from the OMC approved dealers serving their village. A consumer with a connection can obtain a cylinder refill by first booking one through a phone call to her local dealer. Typically, the local dealer delivers booked refills in exchange for empty cylinders by mini trucks within a week of booking. All OMCs sell LPG connections and cylinder refills at the same, unregulated, market price. To elaborate on how the DBT functions, if the market price of an LPG cylinder is 820 rupees, the consumer pays this amount to the LPG dealer at the time of delivery. The dealer enters the refill purchase against the consumers ID in a centralized database. The subsidy amount of 320 rupees is then directly deposited into the consumers linked bank account within 2-3 days of purchase. Since the shift to the DBT system in 2013, corruption through leakages in the LPG subsidy or false reporting of refills are greatly reduced. See Barnwal (2016) for policy changes to stem leakages in the LPG consumption subsidy in India.

[8]This translates as Prime Minister's Brightening Program.

[9]Under the PMUY program, only those women who belong to socio-economically deprived (based on caste and income) households, are entitled to the subsidy of USD 25 to obtain the

that empowers rural women and, therefore, does not emphasize health (or financial subsidy) awareness. While it has been successful in significantly improving rural households access to LPG for cooking, the PMUY program is yet to ensure an increase in LPG usage.[10]

Nationwide, an estimated 79% of the households had an LPG connection in 2018 (PPAC Report, 2018).[11] We focus on rural India since LPG use is much lower than in urban areas with the former having a mean annual consumption of about 4 cylinders and the latter about 8.[12] There are a number of factors, in addition to income, that are important in explaining low demand for LPG in rural India. In forested areas, easy access to firewood reduces demand for LPG. Habit, familiarity, and custom can lead to a preference for traditional fuels even in areas that do not have freely available firewood (Aklin *et al.*, 2015) and LPG costs less than buying firewood from the market (e.g., monthly firewood purchase for a family of 4-5 members is approximately 500-800 rupees). Furthermore, many rural households are unaware of the subsidy on LPG because it is deposited in a bank account that they may not monitor often. Text messages to registered phones intimating customers about the transfer to their bank account are

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connection. While they do not pay the remaining USD 20 at the time of getting the connection they too have to pay for the gas in the first cylinder at market price and stove eventually. Thus, effectively the USD 20 is a loan from the dealer to the consumer which will be recovered from her refill subsidy at some point by the government. Initially, the loan was to be recovered by paying the direct benefit transfer to the OMC instead of the customer every time a PMUY customer purchases a refill of the cylinder. But since April 2018 the government has stopped withholding the direct benefit transfer to the bank accounts of the PMUY beneficiaries to encourage them to increase LPG consumption.

[10]A newspaper article covering the story can be found at https://www.downtoearth.org.in/news/energy/govt-admits-refilling-lpg-cylinders-under-ujjwala-a-challenge-plans-a-new-scheme-63835.

[11]Data from Census (2011b) reveals that 28.5 percent of households in India had access to LPG with 65 percent coverage in urban areas and only 11 percent coverage in rural areas. However, since the launch of PMUY in 2016 access in rural areas has gone up significantly but with large geographical variation - north India (e.g., 44% coverage in Jharkhand) continues to lag behind the south (e.g., 100% coverage in Kerala).

[12]Since LPG sales data are not available publicly; these figures are based on authors' estimates from data shared by OMCs for the study area and media reports (https://www.thehindubusinessline.com/economy/ujjwala-connections-get-three-refills-annually-on-an-average/article25798623.ece).

in English and not the local language (e.g., Hindi, in north India). Physical or remote access to account information on fund availability is limited, particularly for women. Finally, lack of awareness of the health consequences may cause rural households to continue using solid fuels even if they can afford LPG.

3 Research Design

3.1 Sampling

We implement a cluster-RCT in the rural areas of Indore district in Madhya Pradesh (MP), the second-largest Indian state by area and the fifth largest by population with over 75 million residents. Over 60% of households (rural and urban) had an LPG connection in January 2018 (PPAC Report, 2018) in MP. Indore, being the commercial hub with the highest per capita income amongst all districts in MP, is less likely to be subject to supply-side constraints on households' LPG access. The location is, therefore, suitable for examining factors limiting household demand for clean fuels.

We determined the sample size to detect an annual increase in the number of LPG refills purchased by a household of 1 LPG cylinder at 5% significance level for a cluster-RCT study with 80% power. The minimum number of required clusters in each arm is 39, with 20 households per cluster. We decided on 50 clusters or villages in each arm in order to exceed this requirement. The mean, variance, and intra-cluster correlations in annual LPG refill consumption were based on consumer-level data for rural Indore district obtained from the annual sales records of the OMCs.[13] Our aim, therefore, was to select 150 villages and 20 households from each village. We wanted to avoid selecting villages that were too close to each other in order to minimize spillover of information between treatment and control villages. We also wanted to avoid villages that were *de facto* urban or suburban.

There are four census blocks in Indore district – Indore, Mhow, Sanwer, and Depalpur.

[13]The OMC sales data we used for the power calculations are proprietary but the details of the power calculation assumptions and the accompanying results are in the attached read-me file: POWER.

Of these, Indore is primarily urban and was, therefore, excluded from the study. We mapped the remaining 491 villages from the three census blocks into their corresponding 250 *Gram Panchayats* (GP) using administrative data.[14] This was to avoid having more than one village from a GP in the sample to reduce spillovers. We excluded 22 villages with a population exceeding 5000 (and less than 10 households) in order to exclude villages that were *de facto* urban or suburban or too small, leaving us with 239 GPs. From these we randomly sampled 150 GPs and the largest village, by population, from each of these GPs was chosen for our study. All population estimates and other village-level data were based on the 2011 Census of India.

In the sampled villages, a household was deemed eligible for the study if it had a currently residing member either less than 10 years or more than 55 years of age or both – demographic groups which are typically more vulnerable to adverse health effects due to indoor air pollution. 20 households were randomly sampled (conditional on eligibility criterion) in each of these villages by systematic random sampling during the baseline survey.[15]

The RCT design includes three arms - (1) health awareness (H) (2) health and financial subsidy awareness (H+S) (3) no awareness campaign or the control group (C). The 150 villages were, therefore, randomly assigned to one of the three arms with 50 villages in each. However, during the training of the public health workers who are carrying out the intervention, we were informed that 4 villages in each of the two treatment arms either did not currently have an officially appointed health worker (3 villages) or the current worker had a health emergency (unrelated to indoor air pollution, 1 village) or could not be contacted for the training (4 villages). Throughout we will report the Average Treatment Effect on the Treated (ATT) as our main analysis with the original 50 villages assigned to the control group and the 46 villages

[14]The lowest level of local government in India is the *Gram Panchayat*, usually having 2-3 villages. The data for mapping villages into *Gram Panchayats* was obtained from the Local Government Directory (https://lgdirectory.gov.in/downloadDirectory.do)

[15]Following this sampling procedure, first an estimate of the total number of households (N) in the village was obtained by the survey team. Then, every N/20th household, starting from the center of the village and moving in a clockwise direction to come back to the starting point, was selected for the survey.

that are receiving the treatment in each of the two treatment arms.[16]

Figure 2 shows the geographical spread of the sampled villages, by treatment status, across Indore district. Note that the average distance between the centroids of any two nearest neighboring villages in our sample is 1.5 km.

3.2 Baseline survey and intervention

Table 1 shows the timeline of the study. The baseline survey was conducted in November-December, 2018. Households in the sample were asked whether they currently have an LPG connection or not. If they did, details of the connection, including the unique consumer ID, number of refills in the past year were recorded from their consumer booklets accompanied by photographs of the consumer details and refills in the booklet. The LPG consumption data were matched with sales data from the OMCs for validation.[17] Detailed information on household composition, fuel use and collection, health awareness, primary cook's time use, and wellbeing were gathered for all households irrespective of LPG connection status. Appendix. B contains the English translation of the Hindi baseline questionnaire.

Following the baseline, in January 2019, the intervention to increase adoption and regular usage of LPG was initiated. It will end on September 2019. Specifically, we designed an awareness campaign on the health and financial benefits of shifting to regular usage of LPG for cooking. The campaign centered around improving households' understanding of (1) health impacts of solid fuels and (2) the government subsidy to LPG consumers. The awareness campaign leveraged the existing public health system by engaging Accredited Social Health Activists (ASHAs) to provide information to sampled households. ASHAs are female residents of a village, who have completed at least 10th grade, are between 25–45 years of age, and are employed by the state government on piece-rates to provide public health services. Usually, a

[16]We reproduce all analyses described in the next section with the original assignment of 50 villages in each of the three arms in Appendix. A. Later we discuss estimating an Intention to Treat (ITT) effect using the original assignment.

[17]We will conduct a similar exercise of validating the data from OMCs' sales records after the endline survey. The OMCs' sales data are not public but shared with the researchers by the OMCs for the purpose of the study.

village has only one ASHA worker.[18]

ASHAs of the treatment villages were trained by the NGO, Madhya Pradesh Voluntary Health Association (MPVHA), which has been conducting ASHA training modules on behalf of the state administration for several years, along with the research team. The training was conducted over 2 days in the three block headquarters. The ASHA training manuals, translated from Hindi into English, are included in Appendix. C.

During the training ASHAs were first made aware of the adverse health impacts of solid fuels, including a list of diseases, their symptoms, and consequences. They were then provided with hand-held tablets that contained videos, and a campaign manual, and detailed written scripts to follow for up to 6 household visits. The visits were scheduled for the first 15 days of January, February, March, and June, and the last 15 days of August and September. The frequency of these visits is higher during the winter season when solid fuel usage is usually high and lower during the rainy season when households may anyway use LPG more often due to non-availability of dry wood.

The information on health (H) centered around the adverse health effects of household air pollution for all members of the household, with particular emphasis on children and older adults who are more susceptible to respiratory and cardiovascular diseases. The campaign included three customized videos which begin with a depiction of a typical rural household whose kitchen is in a common room in the house, making not just the primary cook but all household members susceptible to inhaling smoke. A licensed medical doctor then talks about long-term health impacts like low birth weight, asthma, cardiovascular disease, and lung cancer, of indoor smoke. Each video focuses on a different set of diseases, and ends with the doctor advising them to stop using wood and other solid fuels and switch to LPG completely.[19] In a

[18]The guidelines framed by the National Rural Health Mission allow for 43 different tasks for ASHAs relating to, for example, immunization, antenatal care, institutional delivery, and family planning. There is a specific remuneration set for each task. The maximum they can earn for an activity is 5,000 rupees for administering medicines to drug-resistant tuberculosis patients to just one rupee for distributing an ORS (oral rehydration solution) packet. Hence their monthly remuneration is directly dependent on their activities in that month. In our intervention ASHAs were paid 50 rupees per visit per household.

[19]In each video, the doctor suggests that the household use electric induction stoves rather

fourth video made of comic strips, we narrate a story in which the main characters (a new bride and her mother-in-law) have conflicting views about using LPG, again aimed primarily at emphasizing the adverse health impacts of traditional, solid fuels.[20] Each video is approximately 2 minutes long.

In the health and financial subsidy treatment arm (H+S), besides the health awareness training, the details of the LPG subsidy and how it operates is also explained. This included discussion of how to obtain a regular or PMUY LPG connection and the direct benefit transferred to the beneficiary bank account on each purchase of up to 12 cylinders per year per connection by the government.[21] The households are to be made aware that their effective out-of-pocket expenditure was no more than Rs. 20 per day in a month if they consumed one 14.2 kg LPG cylinder per month (or approximately 500 rupees per month, post subsidy), the typical requirement of a family of 4-5 members if it cooks exclusively on LPG. Thus the H+S treatment arm provided exactly the same health information, and in addition ASHAs were instructed to explain the LPG subsidy and have discussions on the cost of purchasing refills during each visit.

The treatment group ASHAs were, thus, given a specific scripted task for each of the 6 visits, including instructions on which video(s) to show during each visit and the conversations/discussions to have with the sampled households. The four videos are to be shown in the first three household visits while the remaining three visits reinforce the message with no new information. It is important that ASHAs visit the households when the household head along with the primary cook is available. The ASHAs in the control group villages were not contacted by the research team.

We ensure compliance to the treatment status through regular monitoring of the ASHA workers' performance. Towards this end monitors appointed from the MPVHA, along with the project Research Assistant, conduct meetings within two weeks of the end of the desig-

than solid fuels, if for some reason there is a delay in obtaining an LPG refill.

[20] We are grateful to David Levine for sharing the material for this story with us.

[21] In the H+S arm we also trained ASHA workers on how to register household mobile phones with the OMCs, read the text messages confirming deposit of subsidies and provide information on obtaining refill LPG cylinders, if requested by the household.

nated period for household visits. During the monitoring process the ASHA workers' tablets are checked for photographs taken during the household visit (in which the date and time are displayed) along with back-checks through phone calls to sampled households to enquire about the interaction with the ASHA. Payments to ASHAs for each visit are released only after the entire monitoring process is completed.

To prevent spillover of information to the control group, the ASHAs have been given strict instructions to share the information only with the 20 sampled households in their village, and the tablets were not equipped with chips that would allow the videos to be easily shared. Moreover, since the work area of the ASHAs is restricted to their own village, they are unlikely to extend their domain beyond and impinge upon another ASHA's work area.

Following the completion of the intervention, the endline survey will be conducted in November and December 2019 during which the households surveyed in the baseline will be revisited. During the baseline survey the GPS location of sampled households and their mobile numbers were recorded to enable us to relocate them at endline. Furthermore, since the city of Indore within the district is the largest urban agglomeration in Madhya Pradesh, by size and growth rate, permanent rural migration rates out of the district are reasonably low at around 15% (NSS, 2007-08). Hence, we expect attrition to be negligible, if not absent.

3.3 Descriptive statistics at baseline

Table 2 shows the balance at baseline between the three groups at the village and household level using data from the Census (2011a,b). The top panel reports the average village level amenities, while the bottom panel shows the average household level amenities. We find no significant differences in educational and health facilities between groups. At the household level, the proportion of households using firewood or LPG for cooking is comparable. There are no significant differences in ownership of other amenities such as toilet or tap water either, which may reflect health preferences of households.

In Table 3, we show similar comparisons of household characteristics but from our baseline survey data, dropping the 8 villages that were pre-assigned to the treatment groups but did not comply. Except for pairwise difference in household head's education at 10% signifi-

cance level, there do not appear to be any differences in households observable characteristics or their perceptions regarding effects of solid fuels and trust in ASHAs. Note that more than half the sampled households are either self-employed or salaried (as opposed to wage laborers), suggesting that the sampled population is relatively well-off financially. In Table 4 we report solid fuel and LPG usage of sampled households. The first three rows report proportions unconditional on whether households report using that fuel or not. The remaining rows, on LPG consumption, are conditional on the household having an LPG connection. We do not find differences in usage and access to fuels between the three groups, except in the quantity of dung cakes purchased, at 5% or higher levels of significance. There are no significant differences in LPG refills (approximately 4.6 cylinder refills in the previous 12 months), annually or per month across seasons, conditional on having a connection. Overall, our baseline data shown in Tables 2-4 suggest successful randomization into the three arms at the household level and at the village level (Table 1).

Next, we report households' use of cooking fuels in the previous month (top panel) and during the last meal (bottom panel) in Table 5 to show that even if households have an LPG connection, they tend to use solid fuels frequently and regularly. Indeed, when asked whether the household had used either firewood or dung-cakes or crop-residue in the last month, 75, 88 and 11 percent of all households in the sample, respectively, responded 'yes', even though 74% of the sample had also used LPG for cooking in the previous month. We also asked the primary cook of the household to list all the fuels used in cooking the last meal she had prepared. More than half of the households reported using solid fuels exclusively, even though almost two-thirds have LPG connections. Only 29% of households report using LPG exclusively in preparing the last meal.[22]

[22] 14% (29%) of households report purchasing firewood (dung cakes) worth 790 (698) rupees in the previous month, which is more than the out-of-pocket expenditure on 1 LPG refill (500 rupees). 70% (70%) of households report spending 44 hours (40 hours) in the previous month, on average, collecting firewood (making dung cakes). Given the minimum daily wage for unskilled labor at 280 rupees in Madhya Pradesh, this amounts to these households losing income from up to 5 days of work or 1400 rupees in a month. Thus the opportunity cost of using solid fuels can be substantial, given that the average monthly income of a rural household in the state of Madhya Pradesh was 5672 rupees in 2011 (Desai *et al.*, 2011).

Our premise is that low level awareness of the long-term adverse health effects of solid fuels is pervasive in rural India. To validate this premise we asked the respondents whether they thought there were any health effects of indoor smoke. The findings from the baseline survey are reported in Table 6. Only 13% of the respondents stated that there can be long-term health effects of inhaling smoke from solid fuels. 70% of the households expect only short-term health impacts that cause temporary discomfort and have no long-term implications. There are no significant differences in awareness across the three groups. We also gave the household a list of 9 diseases (in random order), 6 of which can be caused due to indoor smoke (e.g., hypertension) and 3 which were not (e.g., anemia) and asked whether that disease/ailment can occur due to inhaling smoke from solid fuels or not. The scores (with a maximum possible score of 9) are summarized in Table 7. In the top panel we report the statistics for the entire sample, coding the score of households which either said there are none or they don't know of any adverse health effects of inhaling smoke from solid fuels, as 0. The average number of correct responses was 3.87 and only 3% of households correctly identified the 6 ailments due to indoor smoke. The bottom panel restricts the sample to those households which said that there are either short or long-term health effects of inhaling smoke from solid fuels. The proportion of households with all correct responses remains low at 4%.

To summarize, the baseline data show that most households in the study area regularly use solid fuels, including those with an LPG connection, and have poor awareness of the adverse health effects of solid fuels. Our main questions, therefore, are:

- Does information increase households' LPG consumption in terms of number of refills consumed annually and seasonally, and by how much?
- Does bundling information on the LPG subsidy with health awareness enhance the impact of the campaign on households' LPG consumption?
- Does information lead to previously unconnected households obtaining an LPG connection?

4 Empirical Analysis

In this section, we outline the empirical specification to obtain causal estimates of the effects of the awareness campaign on household behavior.

4.1 Primary Outcomes

The primary outcome of our study is the number of LPG refills purchased by a household during the period January-December, 2019. Our first specification clubs exposure to the H (health awareness) or H+S (health + subsidy awareness) campaign into a single indicator of treatment status that takes value one if a household was exposed to either treatment and zero otherwise (control group). The specification estimating the treatment effect in an OLS framework is thus:

$$Y_{iv}^1 = \beta_c + \beta_T T_v + \beta_0 Y_{iv}^0 + \beta_X' \mathbf{X}_{iv} + \beta_Z' \mathbf{Z}_v + \varepsilon_{iv}, \tag{1}$$

where Y_{iv}^1 is the number of refills purchased by the ith household in village v during and after the intervention period. Y_{iv}^0 is the baseline number of refills purchased by the same household (Nov 2017 - Oct 2018). T_v is a dummy variable indicating whether village v is assigned to either treatment or not and $\mathbf{X}_{iv}$ are a set of baseline characteristics for household i in village v. These controls include household size and assets, education and primary occupation of the household head, education and age of the primary cook, indicators for household religion and caste.[23] Finally, we also control for a set of village characteristics, $\mathbf{Z}_v$, measuring the distance of the village v from the block headquarters (in km.), the proportion of irrigated land, and indicators for the presence of private primary schools, health sub-centre, and all weather road access.

The parameter of interest is β_T, which represents the impact of the awareness campaign (either health or health and subsidy) on the consumption of LPG. Since the treatment status

[23] Since ownership of household assets are likely to be highly collinear we use the first component of a principal component analysis over several indicators measuring the economic status of a household. These indicators include ownership of land and farm animals, *pucca* house, and a list of consumer durables. Education of the head of the household and the primary cook is measured by an indicator that takes the value one for above primary education and zeroes otherwise.

was randomly assigned to the sampled villages, households exposure to treatment is entirely exogenous. Therefore, the OLS estimation of β_T from equation (1) is the average treatment effect on the treated (ATT) of the awareness program. If information increases LPG refills then β_T should be significantly positive.

Our second specification distinguishes between the two types of treatments to estimate and compare the impact of the health and subsidy awareness on LPG uptake.

$$Y_{iv}^1 = \beta_c + \beta_T^h T_v^h + \beta_T^{hs} T_v^{hs} + \beta_0 Y_{iv}^0 + \beta_X' \mathbf{X}_{iv} + \beta_Z' \mathbf{Z}_v + \nu_{iv}, \tag{2}$$

where T_v^h is a dummy for assignment of village v to the health awareness treatment and T_v^{hs} a dummy for assignment to the health and subsidy awareness treatment. The other variables are as explained above. If information of long-term health impacts of solid fuels alone increases LPG refills then β_T^h should be significantly positive. If the information on LPG subsidy enhances the health awareness treatment, i.e., the two treatments complement each other, then β_T^{hs} should be positive and significantly larger in magnitude than β_T^h. Standard errors in both specifications in equation (1) and (2) are clustered at the village level.

The district of Indore, our area of study, has three seasons: cold, summer, and wet.[24] Availability and consumption of firewood varies by season in rural India which may, in turn, affect the consumption of LPG.[25] To capture the seasonality in the treatment effects we estimate both (1) and (2) for these three periods. In these specifications, Y_{iv}^0 and Y_{iv}^1 measure the number of refills purchased by a household in winter, summer and wet (rainy) seasons before the beginning of the treatment and after treatment began in January 2019, respectively.

[24]Using the past eight years of temperature and rainfall data from the Indian Meteorological Department we define the period between 16th October to 15th March as cold, 16th March to 15th June as summer, and 16th June to 15th October as wet.

[25]As shown in Table 4, LPG usage is typically higher in the wet or rainy season when dry wood is difficult to obtain and highest in the cold, winter season when households require heat.

4.2 Heterogeneity

The previous section analyses the impact of the awareness campaigns on the adverse health effects of using firewood and information on available subsidies on the consumption of LPG refills. These effects, however, could vary with both demand-side factors, e.g., the economic status of households, education of the household head and the primary cook, decision-making abilities of the primary cook, as well as supply-side factors such as distance to the LPG dealer. We use the specifications outlined earlier to analyze heterogeneity in the impact of the treatment effects in more detail.

As discussed previously, the consumption of LPG refills is subsidized in India. Consumers pay the market price, and subsidies are directly credited to their bank account. As a result, the market price is higher than the effective price. This difference can be substantial for economically disadvantaged and liquidity constrained consumers, and they might be impacted less by the awareness campaigns. To measure this heterogeneity in treatment effects by household wealth, we interact the treatment indicator(s) in equations (1) and (2) with the asset index described earlier and report the estimated coefficient on the interaction and the main effects.To elaborate, a positive coefficient on this interaction term in equation (1) would imply that wealthier households are more likely to purchase additional refills in response to the treatment relative to the less wealthy.

The effect of exposure to the treatment might vary by the level of education of the head of the household and primary cook - more educated households are more likely to understand the long-term implications on health as well as the impact of the subsidy on their out-of-pocket fuel expenditure. To tease out this heterogeneity we interact the treatment indicator(s) in equations (1) and (2) with the education level of household. A positive coefficient on this interaction term in equation (1) would be in line with our hypothesis.

Almost all of the primary cooks in the sampled households are women (only 10 are male) and bear a higher risk of suffering from health issues as a result of inhaling smoke from solid fuels during cooking. We hypothesize that primary cooks' preferences are more likely to move in favor of LPG due to the information treatment. However, male heads of household usually make financial decisions, including fuel purchases. Hence, those households in which

the primary cook had greater say in household decision-making at baseline are more likely to purchase additional refills due to our intervention. Following standard survey instruments, we have collected information on the primary cook's say in decision-making at baseline on: (a) what to cook daily, (b) whether to buy an expensive item, (c) what to do if she falls sick, and (d) what to do if her child falls sick. For each of the questions, the response was categorized as: (1) respondent decides alone, (2) respondent decides along with someone in the household, or (3) respondent is not involved in the decision-making. Since these responses are likely to be collinear, we create a single index using a principal component analysis over the four measures. We interact the treatment indicator(s) in equations (1) and (2) with this index and report the estimated coefficient on the interaction. If the coefficient on the interaction term is positive it would indicate that our hypothesis is correct.

Although supply-side issues are likely to be a weak constraint in Indore, as pointed out earlier, we nevertheless assess how accessibility may impact the usage of LPG. We use the distance of a household from its reported local LPG dealer as a measure of accessibility or supply-side bottlenecks.[26] We hypothesize that households located farther away from their local dealer may face delays in obtaining a cylinder refill. Hence, the impact of treatment on these households may be low, if not insignificant. For both specifications (1) and (2), we interact the treatment indicator(s) with the household's distance to its LPG dealer and report the estimated coefficient on the interaction term and the main effects. If the coefficient on the interaction term is negative, it would suggest that the impact of information on refill purchases diminishes the further away a household is located from its dealer.

Finally, temporal variation in the local market price of LPG due to movements in world prices may also affect consumption, particularly if consumers have financial and liquidity constraints. Hence during months in which the market price of an LPG refill is relatively high,

[26]We measure distance using the geocoded locations of the sampled households and all OMCs' LPG dealerships in Indore district. We are unable to observe the location of the LPG supplier if they are located outside Indore district. However, this information is missing only for 3.9% of the entire sample. For these households we approximate this with their distance to the block headquarter where typically LPG suppliers are located. The average distance of a sampled household to its local dealer is approximately 8 km.

households may defer refill purchase but less so in treatment villages. To estimate the effect of LPG prices and its treatment, we aim to run following specifications:

$$Y^1_{ivm} = \beta_c + \beta_T T_v + \beta_P P_m + \beta_{TP} T_v \times P_m + \beta_0 Y^0_{ivm} + \beta'_X \mathbf{X}_{iv} + \beta'_Z \mathbf{Z}_v + \varepsilon_{ivm}, \tag{3}$$

$$Y^1_{ivm} = \beta_c + \beta^h_T T^h_v + \beta^{hs}_T T^{hs}_v + \beta_P P_m + \beta^h_{TP} \left(T^h_v \times P_m \right) + \beta^{hs}_{TP} \left(T^{hs}_v \times P_m \right) + \beta_0 Y^0_{ivm} + \beta'_X \mathbf{X}_{iv} + \beta'_Z \mathbf{Z}_v + \nu_{ivm}, \tag{4}$$

where Y_{ivm} is the number of refills purchased by household i in village v in month m and P_m is the price of LPG refill in month m. The remaining variables are as explained previously. Hence these specifications correspond to the main OLS specifications, (1) and (2), but are run at a monthly frequency. If the coefficient on P_m is negative but the coefficient on the interaction term is positive, our hypothesis would be validated. Standard errors continue to be clustered at the village level.

4.3 Additional Outcomes

4.3.1 Fuel Usage

Our awareness campaign targeted lower consumption of solid fuels and promoted the use of cleaner LPG for cooking. We expect, therefore, that some households that did not have an LPG connection at baseline and were exposed to the campaign will obtain a connection. Using specifications (1) and (2), we estimate the impact of our intervention on (1) A household having an LPG connection at endline, conditional on not having a connection at baseline. (2) Conditional on not using LPG at baseline, whether a household reports usage of LPG at endline.

Since the campaign highlighted the adverse health effects of the smoke emanating from firewood and dung stoves, we explore whether exposure to treatment increases the likelihood of households having a separate room as the kitchen, an outlet for smoke in the kitchen, and the adoption of electric induction stoves as additional outcome variables (all binary dependent variables). We also analyze the effect of being in the treatment group on self-reported fuel collection (hours per week spent by the household and primary cook on firewood/dung collection or making of dung cakes), fuel consumption (type of fuel used to prepare the most recent meal)

and expenditure on firewood and dung cakes in the month preceding the endline survey.

4.3.2 Household Awareness

The media resources and the ASHA scripts in our intervention attempted to increase the households awareness of the adverse health impact of cooking with solid fuels. Naturally, we expect the treated households to have heightened awareness of the adverse health effects of smoke from solid fuel. We estimate the impact of the treatment on these binary outcome variables that measure households knowledge (refer to Table 7) using the specification outlined in equations (1) and (2). The dependent variable is defined as the number of correct answers out of the 9 diseases.

4.3.3 Health Outcomes

Finally, we estimate the impact of cleaner fuel or LPG on minor and major morbidity for household members, information that was also collected at the baseline. Minor morbidities include cough, chest pain, eye irritation, breathing issues, and pneumonia, in the month preceding the survey. Major morbidities include incidences of asthma, tuberculosis, and lung cancer. When a household reported occurrence of an illness, our baseline survey collected the health expenditure incurred.[27] We use the treatments as instrumental variables to estimate the marginal effect of LPG cylinder refills on health expenditures. The structural equation of the model is as follows

$$Y_{iv}^{1} = \beta_c + \beta_R R_{iv} + \beta_0 Y_{iv}^{0} + \beta_X' \mathbf{X_{iv}} + \beta_Z' \mathbf{Z_v} + \phi_{iv}, \tag{5}$$

where Y_{iv} is the health expenditure incurred by household i in village v in the reference period R_{iv} is the number of refills purchased by the same household in January to October 2019, the period following the start of treatment and preceding the endline survey. Since R_{iv} is most likely to be endogeneous, we instrument for R_{iv} with T_v^h and T_v^{hs} in the first stage given by:

$$R_{iv} = \beta_c + \beta_h T_v^h + \beta_{hs} T_v^{hs} + \beta_0 Y_{iv}^{0} + \beta_X' \mathbf{X_{iv}} + \beta_Z' \mathbf{Z_v} + \phi_{iv}. \tag{6}$$

[27] For health expenditure, the recall period is one month for minor morbidities and one year for major morbidities.

4.3.4 Index of Outcomes

To deal with the issue of multiple comparisons, we will examine treatment effects on an index of fuel use and an index of health outcomes using the index method of Kling *et al.* (2012).

5 Interpretation of Results

A positive coefficient on 'treatment' in specification (1) would signify an increase in the number of LPG refills is due to our awareness campaign. On the extensive margin, if the campaign increases uptake of LPG connections, then we expect a positive coefficient on 'treatment' when the outcome is whether a household has a gas connection or not. For both these outcomes, specification (2) would allow us to measure the complementarities between health and financial subsidy information by comparing the coefficients on H and H+S treatments.

Our estimated ATT effect will capture what outcomes to expect if our intervention were at scale and the information is actually delivered. The ATT may be of wider interest because in future such a campaign may be delivered to the community by public workers or through mass media. As a robustness check, however, we will also report an Intention To Treat (ITT) analysis by using our original assignment of 50 villages each to the three treatment arms. This will capture what to expect if the program were to be scaled up, but taking into account occasional failures to comply with treatment.

To see that our results are indeed due to the awareness campaign, we will collect the same information on households' health awareness at the endline as in the baseline. We should find some increase in households' knowledge of the adverse health effects of solid fuels in the treatment groups vis-À-vis the control group. We will also ask additional questions on households' understanding of the financial subsidy (not asked at baseline) to infer whether improved financial awareness is indeed the mechanism for any observed difference in impact between H and H+S groups.

A possible confounding factor in establishing information as the only mechanism that impacts households' uptake of LPG is that the number of ASHA visits to the treated households is likely to have been higher than for the control group. Our experiment design did not include

placebo visits by ASHAs in the control group given that at baseline only 13% of households were aware of long-term health effects from indoor smoke. It is unlikely that the number of ASHA visits rather than increased awareness could cause households to increase uptake when initial awareness is so low. Nevertheless, we will study the heterogeneity of effects by the intensity of our treatment. At endline, we will ask both sampled households and ASHAs the number of times the ASHA visited the treatment and control households between January and October 2019. Interacting the treatment dummy in equations 1 and 2 with the number of ASHA visits would allow us to measure heterogeneity of impacts within the treated villages and relative to the control group.[28]

Another related concern is whether the nature of the campaign, rather than information per se, impacted behavior. To elaborate, our awareness campaign was conducted by existing public health workers who are also residents in the same village. If the campaign were to be conducted through impersonal text messages or unfamiliar informants would effect sizes be the same? To answer this question we will measure the heterogeneity of response to treatment on LPG refill consumption by households' trust in ASHAs from our baseline survey.[29] Furthermore, treatment impacts may have varied by peer effects between the ASHA and respondent or among treated households. One possible measure of peer effects is the caste homogeneity of a village. If more of our sampled households belong to the same caste group as the ASHA, spillovers through peer effects may be stronger. We also hope to obtain aggregate village level data from the OMCs on LPG usage over time to measure spillovers better.

[28]We have also included questions on general health–seeking behavior and knowledge that relate to the typical health issues addressed by ASHAs (e.g., iodine and iron deficiency) and behavior (e.g., health check-up for hemoglobin), unrelated to solid fuels, at baseline. We will ask these questions again at the endline. If we find an increase in awareness on health issues unrelated to solid fuels in the treatment group relative to the control at endline, it could suggest that the number of ASHA visits also had an impact on household behavior.

[29]At baseline, we had asked all households "Do you think that the ASHA workers give you correct health information?" Yes/No

6 Conclusion

In this study we conduct a cluster randomized control trial to investigate whether creating awareness on the adverse health effects of inhaling smoke from solid fuels used for cooking can induce households to adopt and use LPG, a clean fuel, more regularly in rural India. We vary our door-to-door campaign by bundling health awareness with financial information on the existing LPG subsidy provided by the government in another treatment arm. We then analyze the take-up and usage of LPG by households in villages in the health, and health plus subsidy awareness treatments vis-À-vis the control group of villages which received no information.

In the event that the intervention exhibits increased awareness and more regular usage of LPG, it would suggest a low-cost policy tool that could be adopted under the existing public health system to reduce air pollution in one of the most polluted countries in the world.[30] More generally, raising awareness of the health effects of cooking smoke through mass media and other means would make it to the agenda of policy-makers, not only in India but in all countries facing similar issues.

7 Disclaimer & Administrative Information

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[30]Each ASHA receives 50 rupees per household per visit which equals 300 rupees for 6 visits per household. Fixed costs were incurred on creating the videos (800,000 rupees) and ASHA training (500 rupees per ASHA +incidentals). The variable costs, therefore, are very low at approximately USD 5 per household. Valuing the benefits, on the other hand, requires an assumption about reduction in air pollution associated with an additional LPG cylinder and the resulting monetary value of the positive health effects of this reduction. Data on morbidity related to air pollution are unavailable which makes it difficult to calculate these benefits. But the variable costs of our campaign are very low, and when scaled up, the fixed costs would be negligible.

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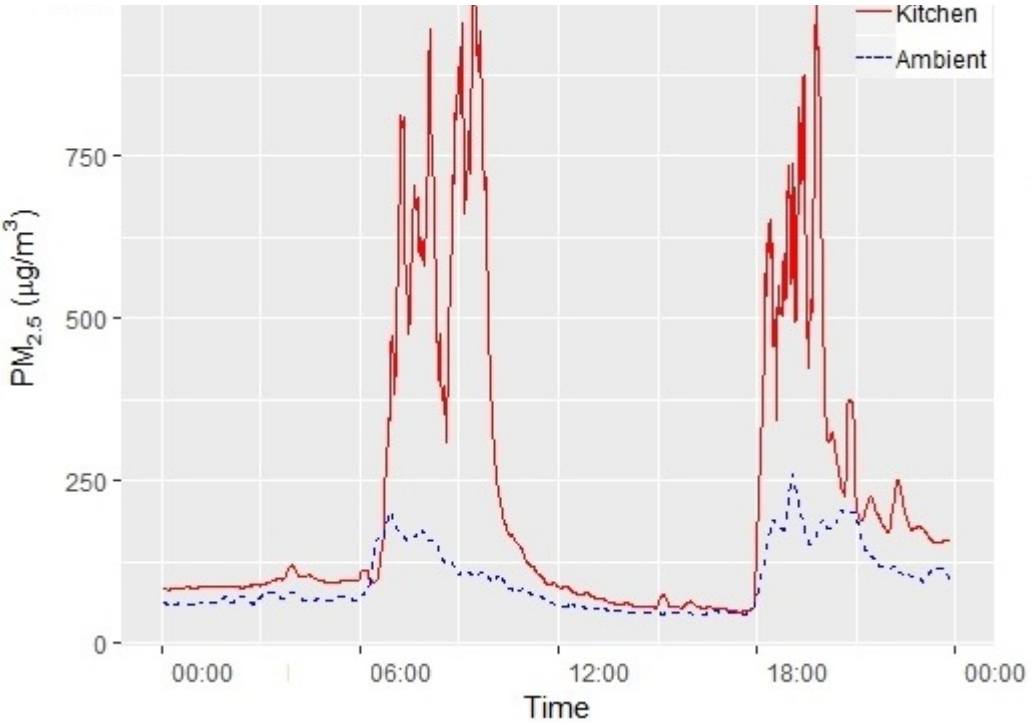
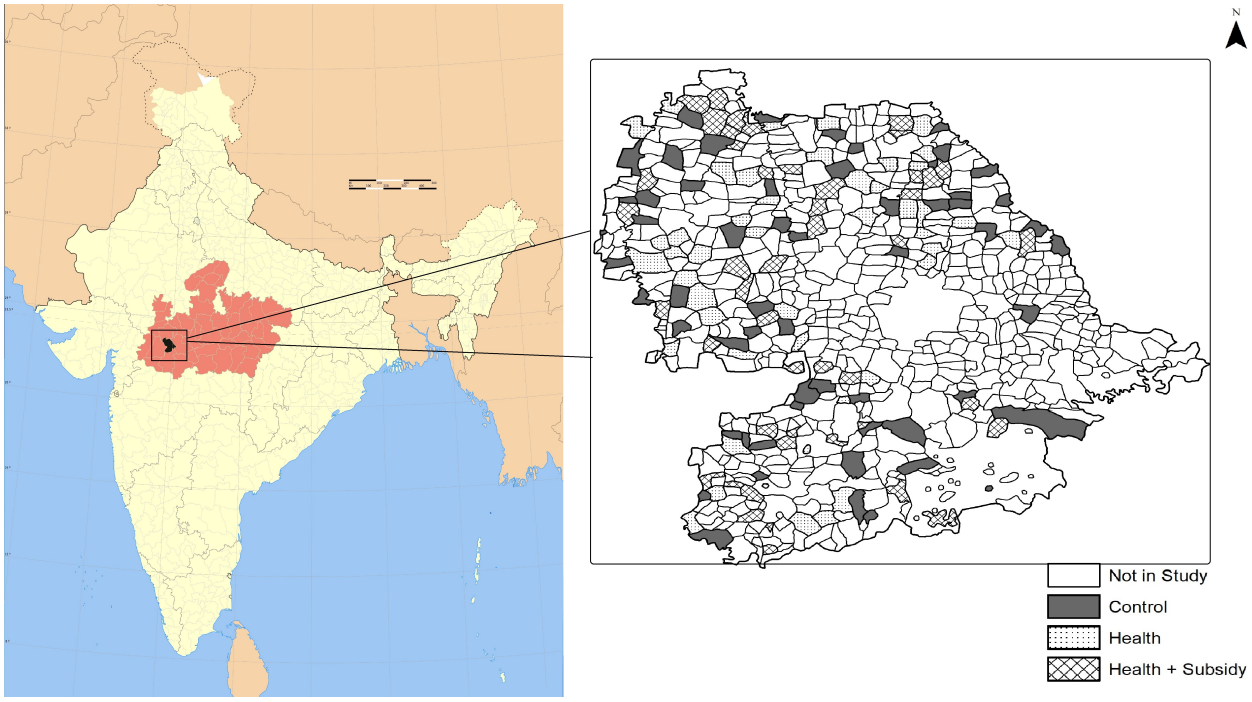
FIGURE 1: Indoor and Outdoor PM2.5 Concentrations in a North-Indian Village



Notes: The solid line plots 15-minute moving averages of PM2.5 concentrations over a day (10 February 2019) measured in the kitchen of a household that cooks with solid fuels in a north Indian village. The dashed line shows data from an outdoor sensor in the same village and date. Both measures of PM2.5 are at one-minute resolution.
Source: Somanathan *et al.* (2019).

FIGURE 2: Map of Study Area by Treatment Status of Villages



Notes: Indore block and the urban areas of the district (viz. the city of Indore, in the middle of the district) were not part of the study. The southern part of the district has few habitations due to significant forest cover.

TABLE 1: Timeline of the Study

Date	***Round***	***Data***	***Sample***
Nov-Dec, 2018	Baseline	Household survey	150 villages 3000 households
Jan-Sept, 2019	***Information campaign***		92 villages 1840 households
Nov-Dec, 2019	Endline	Household survey	150 villages 3000 households

Notes: The baseline survey covered the rural areas in the district of Indore. Since there might be seasonality in the consumption of LPG, the endline survey will be administered during November–December 2019.

TABLE 2: Balance of Village and Household Amenities using Census 2011 Data

	Control	***Treatment***		***Difference***		
	C (N=50)	**H** (N=46)	**H + S** (N=46)	**C - H**	**C - (H + S)**	**H - (H+S)**
	(1)	(2)	(3)	(4)	(5)	(6)
Village amenities						
Total Households	279.48	323.26	290.61	-43.78	-11.13	32.65
	(25.63)	(23.86)	(22.56)	(35.02)	(34.15)	(32.84)
Proportion SC/ST population	0.36	0.34	0.39	0.02	-0.03	-0.05
	(0.03)	(0.03)	(0.04)	(0.04)	(0.05)	(0.05)
Pvt. primary school	0.30	0.35	0.35	-0.05	-0.05	0.00
	(0.07)	(0.07)	(0.07)	(0.10)	(0.10)	(0.10)
Govt. middle school	0.72	0.85	0.74	-0.13	-0.02	0.11
	(0.06)	(0.05)	(0.07)	(0.08)	(0.09)	(0.08)
Primary health sub center	0.26	0.33	0.26	-0.07	-0.00	0.07
	(0.06)	(0.07)	(0.07)	(0.09)	(0.09)	(0.10)
Treated tap water	0.16	0.22	0.11	-0.06	0.05	0.11
	(0.05)	(0.06)	(0.05)	(0.08)	(0.07)	(0.08)
Open drainage	0.66	0.63	0.63	0.03	0.03	-0.00
	(0.07)	(0.07)	(0.07)	(0.10)	(0.10)	(0.10)
Proportion of irrigated land	0.60	0.57	0.61	0.02	-0.02	-0.04
	(0.04)	(0.04)	(0.03)	(0.05)	(0.05)	(0.05)
All weather road	0.82	0.80	0.74	0.02	0.08	0.07
	(0.05)	(0.06)	(0.07)	(0.08)	(0.09)	(0.09)
Household amenities						
Own house	93.48	95.06	95.27	-1.58	-1.79	-0.21
	(1.10)	(0.97)	(1.07)	(1.47)	(1.53)	(1.45)
Use fire-wood	48.80	41.06	51.83	7.75	-3.03	-10.77
	(4.96)	(4.86)	(5.47)	(6.95)	(7.38)	(7.32)
Use LPG/PNG	13.05	13.47	11.36	-0.42	1.69	2.11
	(2.34)	(2.10)	(2.16)	(3.15)	(3.19)	(3.01)
Have treated tap water	4.81	5.42	5.07	-0.61	-0.26	0.35
	(1.52)	(2.01)	(2.23)	(2.52)	(2.70)	(3.00)
Have latrine within house	33.29	33.06	29.31	0.23	3.98	3.75
	(2.78)	(2.30)	(2.94)	(3.61)	(4.05)	(3.74)
Own television	45.58	46.28	42.20	-0.70	3.38	4.08
	(2.22)	(1.99)	(2.88)	(2.98)	(3.64)	(3.50)
p-values for joint significance	-	-	-	0.92	0.98	0.65

Notes: We use amenities data at the village and household level from the 2011 Census. We have dropped four villages from each treatment arm due to noncompliance. **H** denotes health only information and **H + S** implies health and subsidy information. Standard errors are reported in parentheses. The *p*-values reported in the last row of the table corresponds to the F-test for joint significance of village- and household-level amenities in determining the treatment status in a linear probability model.

TABLE 3: Balance of Household Characteristics using Baseline Survey Data

	Control	***Treatment***		***Difference***		
	C (N=1000)	**H** (N=920)	**H + S** (N=920)	**C - H**	**C - (H + S)**	**H - (H+S)**
	(1)	(2)	(3)	(4)	(5)	(6)
Household size	6.14	6.16	6.14	-0.01	0.01	0.02
	(0.08)	(0.07)	(0.07)	(0.13)	(0.13)	(0.13)
Female headed hh.	0.06	0.05	0.07	0.01	-0.01	-0.02
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Age of primary cook	34.10	33.81	33.42	0.29	0.68	0.39
	(0.37)	(0.37)	(0.37)	(0.72)	(0.68)	(0.62)
Household head edu. above primary	0.42	0.43	0.37	-0.01	0.04	0.06*
	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)
Hh. head self-employed or salaried	0.51	0.53	0.50	-0.02	0.02	0.03
	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)
SC/ST	0.39	0.40	0.43	-0.01	-0.04	-0.03
	(0.02)	(0.02)	(0.02)	(0.04)	(0.05)	(0.05)
OBC	0.44	0.42	0.43	0.02	0.00	-0.01
	(0.02)	(0.02)	(0.02)	(0.05)	(0.05)	(0.05)
Hindu	0.93	0.93	0.89	-0.00	0.04	0.04
	(0.01)	(0.01)	(0.01)	(0.04)	(0.04)	(0.05)
Trust info. from ASHA	0.83	0.81	0.84	0.02	-0.01	-0.03
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)
p-values for joint significance	-	-	-	1.00	0.70	0.55

Notes: We use the baseline survey data collected by the authors. We have dropped four villages from each treatment arm due to noncompliance. **H** denotes health only information and **H + S** implies health and subsidy information. Standard errors clustered at the village level are reported in parentheses. The *p*-values reported in the last row of the table corresponds to the F-test for joint significance of household characteristics in determining the treatment status in a linear probability model.

TABLE 4: Balance of Household Fuel Consumption using Baseline Survey Data

	Control	***Treatment***		***Difference***		
	C (N=1000)	**H** (N=920)	**H + S** (N=920)	**C - H**	**C - (H + S)**	**H - (H+S)**
	(1)	(2)	(3)	(4)	(5)	(6)
Qty. of firewood purchased last month (kg)	11.94	18.57	15.15	-6.63	-3.21	3.42
	(2.06)	(4.32)	(2.69)	(5.34)	(3.60)	(5.46)
Qty. of dung cakes purchased last month	20.57	39.83	32.50	-19.26**	-11.94**	7.32
	(2.22)	(9.51)	(3.62)	(9.70)	(5.08)	(10.28)
LPG connection	0.65	0.71	0.67	-0.06*	-0.02	0.04
	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)
PMUY beneficiary	0.34	0.35	0.39	-0.00	-0.04	-0.04
	(0.02)	(0.02)	(0.02)	(0.05)	(0.05)	(0.05)
Total no. of refills (annual)	4.61	4.52	4.62	0.09	-0.01	-0.09
	(0.13)	(0.13)	(0.13)	(0.32)	(0.33)	(0.31)
No. of LPG refills per month (summer)	0.36	0.37	0.38	-0.01	-0.02	-0.01
	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)	(0.03)
No. of LPG refills per month (wet)	0.41	0.40	0.41	0.01	-0.01	-0.01
	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)	(0.03)
No. of LPG refills per month (winter)	0.37	0.35	0.36	0.02	0.01	-0.01
	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)	(0.03)

Notes: We use the baseline survey data collected by the authors. We have dropped four villages from each treatment arm due to noncompliance. **H** denotes health only information and **H + S** implies health and subsidy information. Standard errors clustered at the village level are reported in parentheses.

TABLE 5: Households' Cooking Fuel Usage using Baseline Survey Data

Fuel type	Proportion of total households	Number of households
Cooking fuel usage (last month)		
Firewood	0.75	2121
Crop-residue	0.11	320
Dung cakes	0.88	2490
LPG	0.74	2107
Cooking fuel usage (last meal)		
Solid fuel (along with other fuels)	0.69	1960
Only solid fuel	0.54	1538
LPG (along with other fuels)	0.44	1253
Only LPG	0.29	824
Electricity	0.03	71

Notes: In the top panel the respondent was asked "Did you cook with FUEL in the last month?" The proportion saying "yes" is mentioned against each fuel. For the fuel usage in last meal (bottom panel), the primary cook was asked to recall the most recent main meal that she cooked in the last twenty-four hours and then asked "Which fuel(s) did you use to prepare this meal?" The respondent then chose all the fuels that were used in cooking the most recent meal. We have dropped four villages from each treatment arm due to noncompliance. All proportions are reported of the total sample of 2840 households.

TABLE 6: Households' Perceptions of Health Impacts of Solid Fuels using Baseline Survey Data

	Proportion			
	All	**C**	**H**	**H + S**
Number of households	2840	1000	920	920
No effects	0.16	0.15	0.15	0.17
Short-term effects	0.70	0.69	0.71	0.69
Long-term effects	0.13	0.14	0.12	0.12
Do not know	0.02	0.02	0.02	0.02

Notes: Response to the question "Do you think that smoke from cooking with wood, dung or other traditional fuels has any adverse health effect on you and your family?" (0) No (1) Yes, short-term effects (3) Yes, long-term effects (4) Don't know. We have dropped four villages from each treatment arm due to noncompliance. All proportions are reported of the total sample of 2840 households.

TABLE 7: Households' Knowledge of Health Impacts of Solid Fuels using Baseline Survey Data

	All	**C**	**H**	**H + S**
Panel A: Full sample				
Number of households	2840	1000	920	920
Health awareness score (out of 9)	3.87	3.80	3.99	3.83
All correct responses (%)	0.03	0.04	0.03	0.03
Panel B: Those who consider smoke from firewood as potential source for short- & long-term illness				
Number of households	2336	824	765	747
Health awareness score (out of 9)	4.70	4.61	4.80	4.71
All correct responses (%)	0.04	0.05	0.04	0.03

Notes: Health awareness score and all correct responses are derived from responses to the questions "Do you think that AILMENT can occur due to inhaling smoke from solid fuels?" (0) No (1) Yes (2) Don't know. We asked each respondent's awareness on a total of nine AILMENTS. Among them low birth weight, pneumonia, tuberculosis, heart disease, cataract, and lung cancer are caused by smoke while polio, diabetes, and anemia are not caused by smoke from firewood. These diseases were listed in a random order. The health awareness score counts the number of correct responses to these nine questions, therefore, it can take integral values between zero and nine. All correct responses is an indicator that takes the value one if a respondent identifies all AILMENTS caused (and not caused) by smoke from solid-fuel correctly. We have dropped four villages from each treatment arm due to noncompliance. All proportions are reported of the total sample of 2840 households.

Appendix. A Full Sample Analysis

TABLE A.1: Balance of Village and Household Amenities using Census 2011 Data

	Control	***Treatment***		***Difference***		
	C (N=50)	**H** (N=50)	**H + S** (N=50)	**C - H**	**C - (H + S)**	**H - (H+S)**
	(1)	(2)	(3)	(4)	(5)	(6)
Village amenities						
Total Households	279.48	321.96	278.18	-42.48	1.30	43.78
	(25.63)	(22.87)	(21.74)	(34.35)	(33.61)	(31.56)
Proportion SC/ST population	0.36	0.35	0.38	0.02	-0.02	-0.03
	(0.03)	(0.03)	(0.04)	(0.04)	(0.05)	(0.05)
Pvt. primary school	0.30	0.34	0.32	-0.04	-0.02	0.02
	(0.07)	(0.07)	(0.07)	(0.09)	(0.09)	(0.09)
Govt. middle school	0.72	0.84	0.72	-0.12	-0.00	0.12
	(0.06)	(0.05)	(0.06)	(0.08)	(0.09)	(0.08)
Primary health sub center	0.26	0.32	0.24	-0.06	0.02	0.08
	(0.06)	(0.07)	(0.06)	(0.09)	(0.09)	(0.09)
Treated tap water	0.16	0.20	0.10	-0.04	0.06	0.10
	(0.05)	(0.06)	(0.04)	(0.08)	(0.07)	(0.07)
Open drainage	0.66	0.64	0.64	0.02	0.02	-0.00
	(0.07)	(0.07)	(0.07)	(0.10)	(0.10)	(0.10)
Proportion of irrigated land	0.60	0.56	0.60	0.04	-0.01	-0.04
	(0.04)	(0.04)	(0.03)	(0.05)	(0.05)	(0.05)
All weather road	0.82	0.80	0.74	0.02	0.08	0.06
	(0.05)	(0.06)	(0.06)	(0.08)	(0.08)	(0.08)
Household amenities						
Own house	93.48	94.88	95.43	-1.41	-1.95	-0.54
	(1.10)	(0.92)	(0.99)	(1.43)	(1.48)	(1.35)
Use fire-wood	48.80	41.49	49.14	7.32	-0.33	-7.65
	(4.96)	(4.73)	(5.21)	(6.85)	(7.19)	(7.03)
Use LPG/PNG	13.05	13.44	10.99	-0.39	2.06	2.45
	(2.34)	(2.01)	(2.02)	(3.08)	(3.09)	(2.84)
Have treated tap water	4.81	4.99	4.71	-0.18	0.10	0.28
	(1.52)	(1.86)	(2.06)	(2.40)	(2.56)	(2.77)
Have latrine within house	33.29	33.28	29.66	0.02	3.63	3.61
	(2.78)	(2.45)	(2.84)	(3.71)	(3.98)	(3.75)
Own television	45.58	46.06	41.78	-0.48	3.80	4.28
	(2.22)	(1.96)	(2.70)	(2.96)	(3.49)	(3.33)
p-values for joint significance	-	-	-	0.97	0.98	0.74

Notes: We use amenities data at the village and household level from the 2011 Census. **H** denotes health only information and **H + S** implies health and subsidy information. Standard errors are reported in parentheses. The *p*-values reported in the last row of the table corresponds to the F-test for joint significance of village- and household-level amenities in determining the treatment status in a linear probability model.

TABLE A.2: Balance of Household Characteristics using Baseline Survey Data

	Control	***Treatment***		***Difference***		
	C (N=1000)	**H** (N=1000)	**H + S** (N=1000)	**C - H**	**C - (H + S)**	**H - (H+S)**
	(1)	(2)	(3)	(4)	(5)	(6)
Household size	6.14	6.18	6.13	-0.04	0.01	0.05
	(0.08)	(0.07)	(0.07)	(0.14)	(0.13)	(0.13)
Female headed hh.	0.06	0.05	0.07	0.01	-0.01	-0.02*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Age of primary cook	34.10	33.81	33.47	0.29	0.63	0.34
	(0.37)	(0.36)	(0.35)	(0.70)	(0.67)	(0.59)
Household head edu. above primary	0.42	0.43	0.37	-0.01	0.05	0.06*
	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)
Hh. head self-employed or salaried	0.51	0.53	0.50	-0.02	0.02	0.03
	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)
SC/ST	0.39	0.41	0.41	-0.02	-0.03	-0.01
	(0.02)	(0.02)	(0.02)	(0.04)	(0.05)	(0.05)
OBC	0.44	0.43	0.44	0.01	0.00	-0.01
	(0.02)	(0.02)	(0.02)	(0.05)	(0.05)	(0.05)
Hindu	0.93	0.94	0.90	-0.01	0.03	0.04
	(0.01)	(0.01)	(0.01)	(0.04)	(0.04)	(0.04)
Trust info. from ASHA	0.83	0.81	0.84	0.02	-0.01	-0.03
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)
p-values for joint significance	-	-	-	0.99	0.79	0.50

Notes: We use the baseline survey data collected by the authors. **H** denotes health only information and **H + S** implies health and subsidy information. Standard errors clustered at the village level are reported in parentheses. The *p*-values reported in the last row of the table corresponds to the F-test for joint significance of household characteristics in determining the treatment status in a linear probability model.

TABLE A.3: Balance of Household Fuel Consumption using Baseline Survey Data

	Control	***Treatment***		***Difference***		
	C (N=1000)	**H** (N=1000)	**H + S** (N=1000)	**C - H**	**C - (H + S)**	**H - (H+S)**
	(1)	(2)	(3)	(4)	(5)	(6)
Qty. of firewood purchased last month (kg)	11.94	17.75	16.18	-5.82	-4.25	1.57
	(2.06)	(3.99)	(2.64)	(5.03)	(3.69)	(5.22)
Qty. of dung cakes purchased last month	20.57	39.23	32.16	-18.67**	-11.59**	7.08
	(2.22)	(8.80)	(3.39)	(9.07)	(4.94)	(9.61)
LPG connection	0.65	0.70	0.67	-0.06*	-0.02	0.03
	(0.02)	(0.01)	(0.01)	(0.03)	(0.03)	(0.03)
PMUY beneficiary	0.34	0.35	0.40	-0.01	-0.05	-0.04
	(0.02)	(0.02)	(0.02)	(0.05)	(0.05)	(0.05)
Total no. of refills (annual)	4.61	4.51	4.57	0.10	0.04	-0.06
	(0.13)	(0.12)	(0.12)	(0.32)	(0.32)	(0.30)
No. of LPG refills per month (summer)	0.36	0.37	0.38	-0.00	-0.01	-0.01
	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)	(0.03)
No. of LPG refills per month (wet)	0.41	0.40	0.41	0.01	-0.00	-0.01
	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)	(0.03)
No. of LPG refills per month (winter)	0.37	0.35	0.36	0.02	0.02	-0.00
	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)	(0.03)

Notes: We use the baseline survey data collected by the authors. **H** denotes health only information and **H + S** implies health and subsidy information. Standard errors clustered at the village level are reported in parentheses.

TABLE A.4: Households' Cooking Fuel Usage using Baseline Survey Data

Fuel type	Proportion of total households	Number of households
Cooking fuel usage (last month)		
Firewood	0.75	2251
Crop-residue	0.12	351
Dung cakes	0.88	2639
LPG	0.74	2227
Cooking fuel usage (last meal)		
Solid fuel (along with other fuels)	0.69	2069
Only solid fuel	0.54	1626
LPG (along with other fuels)	0.44	1322
Only LPG	0.29	873
Electricity	0.02	73

Notes: In the top panel the respondent was asked "Did you cook with FUEL in the last month?" The proportion saying "yes" is mentioned against each fuel. For the fuel usage in last meal (bottom panel), the primary cook was asked to recall the most recent main meal that she cooked in the last twenty-four hours and then asked "Which fuel(s) did you use to prepare this meal?" The respondent then chose all the fuels that were used in cooking the most recent meal. All proportions are reported of the total sample of 3000 households.

TABLE A.5: Households' Perceptions of Health Impacts of Solid Fuels using Baseline Survey Data

	Proportion			
	All	**C**	**H**	**H + S**
Number of households	3000	1000	1000	1000
No effects	0.16	0.15	0.15	0.16
Short-term effects	0.70	0.69	0.70	0.70
Long-term effects	0.13	0.14	0.13	0.12
Do not know	0.02	0.02	0.02	0.02

Notes: Response to the question "Do you think that smoke from cooking with wood, dung or other traditional fuels has any adverse health effect on you and your family?" (0) No (1) Yes, short-term effects (3) Yes, long-term effects (4) Don't know

TABLE A.6: Households' Knowledge of Health Impacts of Solid Fuels using Baseline Survey Data

	All	**C**	**H**	**H + S**
Panel A: Full sample				
Number of households	3000	1000	1000	1000
Health awareness score (out of 9)	3.88	3.80	3.97	3.87
All correct responses (%)	0.03	0.04	0.03	0.02
Panel B: Those who consider smoke from firewood as potential source for short- & long-term illness				
Number of households	2473	824	829	820
Health awareness score (out of 9)	4.70	4.61	4.78	4.72
All correct responses (%)	0.04	0.05	0.03	0.03

Notes: Health awareness score and all correct responses are derived from responses to the questions "Do you think that AILMENT can occur due to inhaling smoke from solid fuels?" (0) No (1) Yes (2) Don't know. We asked each respondent's awareness on a total of nine AILMENTS. Among them low birth weight, pneumonia, tuberculosis, heart disease, cataract, and lung cancer are caused by smoke while polio, diabetes, and anemia are not caused by smoke from firewood. These diseases were listed in a random order. The health awareness score counts the number of correct responses to these nine questions, therefore, it can take integral values between zero and nine. All correct responses is an indicator that takes the value one if a respondent identifies all AILMENTS caused (and not caused) by smoke from solid-fuel correctly.