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Adoption of liquefied petroleum gas stoves in Guatemala: A mixed-methods study

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Abstract

Household air pollution (HAP) is the sixth leading risk factor for premature mortality in Guatemala. Households in Guatemala are gradually adopting liquefied petroleum gas (LPG) stoves, but a strong tradition of woodstove use persists. We conducted a mixed-methods study of LPG stove use in peri-urban Guatemala. We used Knowledge, Attitudes and Practices surveys with 187 LPG stove owners who also used woodstoves to identify perceptions of stove and cooking practices. Barriers to sustained use of LPG stoves were evaluated through focus groups, participant observations with stove users, and key informant interviews with community leaders. Seven themes emerged that explain household decisions to use LPG stoves: (1) the “new technology” should be framed in terms of what the “old technology” lacks, (2) income is not a predictor of gas stove acquisition but may predict sustained use, (3) men are key decision-makers but messages about LPG do not target them, (4) when stoves are viewed as “prize possessions” they may not be used, (5) collective fear about gas stoves is not based on personal experience, but on “stories we hear”, (6) sustained LPG use is hampered by two major factors, seasonally available wood and LPG retailers who are perceived as dishonest, and (7) wood fuel collection is a time to enjoy the company of friends and family and is not “drudgery”. National policies should promote the use of clean cookstove technologies in peri-urban and rapidly urbanizing areas in Guatemala where LPG stoves are in use, but used intermittently, instead of the current plan to install 100,000 “improved” woodstoves by 2032. This could be done by improving dependable cylinder distribution services, targeting gas safety and promoting positive health messages that appeal to men, as well as women.

Keywords

household air pollution; liquefied petroleum gas; Knowledge, Attitudes and Practices surveys; Guatemala; mixed-methods

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Introduction

Globally, nearly 3 billion people use solid cooking fuels. Household air pollution (HAP) causes an estimated 2.6 million deaths annually (Evaluation 2017). Liquefied petroleum gas (LPG) stoves can dramatically reduce HAP when fully adopted (Naeher et al. 2007). However, factors that lead to the adoption and sustained use of gas stoves are not well understood, especially in urbanizing areas that are more likely to purchase solid fuel compared to rural areas relying on freely collected fuels. In urban and peri-urban areas, households are increasingly adopting gas stoves. Besides improved health, co-benefits of clean cookstoves are better quality of life (Alexander et al. 2014), more time to pursue education and work opportunities (WHO 2014) and household cleanliness (Rosenbaum et al. 2015). But are these the reasons that households in periurban areas choose to use gas stoves? If households adopt clean cookstoves, what are the limitations to using them exclusively?

In 2016, HAP was the eighth leading risk factor for premature mortality globally and the sixth leading cause in Guatemala where the present study was located (Evaluation 2017). In Guatemala, 50.1% of urban households and 93.4% of rural households use wood for cooking (Estadística 2015), but households are gradually adopting liquefied petroleum gas (LPG) stoves. In Guatemala, approximately 81% of urban and 19% of rural households use LPG stoves (Estadística 2015). Guatemala primarily imports petroleum products, including LPG. Domestic consumption of LPG has increased from 2.8 million barrels in 2010 to 4.3 million barrels in 2016. The cost of one gallon of LPG dropped from US\$2.49 in 2010 to US \$2.11 in 2016, making LPG more affordable. There are four private distributors of LPG, with the largest distributor controlling 55% of the market. The consumption/importation ratio is 65% indicating that there are adequate reserves of LPG (Minas 2017b). The most common LPG cylinder is the 25-pound cylinder, although there are also 50-pound and 100-pound cylinders for those who can afford larger cylinders. Cylinders are recirculated among different distributors, where they are refilled at local LPG processing plants and sold through certified distributors. These distributors either sell cylinders to customers in their shops or deliver cylinders to homes on trucks or motorcycles for a small additional fee.

For wood stove users, switching to gas stoves may be hindered by the initial cost of the LPG stove (Edwards and Langpap 2005). However, cultural barriers, such as food preferences, stoves used for heating and lighting, and stove functionality may be significant additional barriers (Mukhopadhyay et al. 2012, Bielecki and Wingenbach 2014, Hollada et al. 2017, Kumar et al. 2017). This study sought to evaluate the drivers and determinants of LPG stove use among households that used both gas and wood stoves. The study was conducted in a single peri-urban Guatemalan community in 2015–16, in the Department of Sacatepéquez, an area that is rapidly urbanizing and where 61% of homes own wood stoves and 67% of the homes own a gas stove (Estadística 2015).

Methods

Knowledge, Attitudes, and Practices (KAP) survey

We assessed knowledge, attitudes, and practices (KAP) using a verbally-administered semistructured survey. Survey questions included: (1) household information, (2) food preparation, (3) gas stove use and acceptance, (4) household practices around wood stove use, (5) use of multiple stoves, or stove-stacking, and (6) health and well-being, totaling 109 questions. We used stratified random sampling of census data to ensure inclusion of heterogeneous households within all four districts (*cantones*) of Alotenango. Each district was divided into sectors (blocks) and a random sample of households were chosen in each block. Fieldworkers approached households, which were selected based on eligibility criteria: women were included if they stated that they had an LPG stove and that were willing to participate in one of, or all, of the data collection procedures. If they did not meet the criteria, fieldworkers went to the third household on the same side of the street on that same block to determine eligibility, with the goal of obtaining a representative sample.

In-depth Interviews

We conducted in-depth interviews and participant observations to explore emergent themes from KAP surveys with 33 participants about cooking processes, perceptions of stoves, fuel collection and impacts on health and well-being, with the aim of understanding household decisions around LPG stove use. Respondents included community leaders (n=3), gas/stove retailers (n=6), tortilla vendors (n=3), new LPG users (n=14), and wood and gas (mixed) fuels users (n=7). We conducted participatory and non-participatory observations with 10 participants, starting our observations before lunch preparation with wood collection, until they finished a cooking task, usually 40–90 minutes. Ethnographic observation method was used to witness aspects in the daily lives of participants that would allow us to identify ‘inexplicit’ and ‘tacit’ habits that otherwise would have been difficult to account for (DeWalt and DeWalt 2011). Participant observation allows for immersion into day-to-day lives. Consequently, people’s behaviors begin to reveal what is at stake, why people prefer some cooking methods and not others, why people prefer one stove over other, and why people perceive things in one way and not in another.

Focus Groups

We conducted seven focus groups with 47 participants (averaging 6–7 persons per group). All participants were randomly selected from KAP as follows: (1) wood stove only, (2) wood and gas, and (3) gas stove only. Because women’s spouses are pivotal in decisions to use LPG, we conducted one focus group with men. We explored themes that emerged from the KAP survey that would explain household decisions to use LPG stoves including: (1) cooking practices, (2) perceptions of LPG, (3) food preparation practices, (4) health issues, and (5) fuel consumption and use.

Stove use monitoring

We monitored stove use in 62 households with LPG stoves one week each month during a 6-month period using small temperature sensors (SUMs) that measured stove usage at 1 -

minute intervals (iButtons; Maxim Integrated). We placed sensors on all stoves and open fires. We generated mean daily temperature and standard deviation (SD) for each SUMs and determined that the stove was in use if the instantaneous temperature reading was 1.5 SD (chimney stove), 2 SD (gas stove) or 2 SD (open fire) greater than the mean daily temperature. We summed total time each stove was in use during the monitoring period and standardized to hours/week for comparison across different stoves. Additionally, the percentage of cooking time represented by gas was determined by dividing the median hours of gas stove use by the total cooking time across all gas and wood stoves. To determine significant differences in stove use by demographic factors, generalized estimating equations were used to account for intra-person correlation on multiple household measurements in the analysis of stove use. An overview of methods is described in Table 1.

Mixed Methods Data Analysis

We used grounded theory methodology (Glaser 1967, 1978, 1992, 1998, Strauss and Corbin 1998) to analyze qualitative data inductively. Using mixed-research methods, we investigated what motivates women to use a particular fuel or stove. Informant-driven qualitative findings were linked to quantitative findings to contextualize meaningful data. Qualitative and quantitative interviews were conducted sequentially and triangulated during analysis (Bryman 2006). In-depth interviews and focus groups were conducted in Spanish and audio-recorded. Interviews were transcribed verbatim and transcripts were coded and analyzed thematically in Spanish using ATLAS.ti software (version 8.0.33)

Ethical Approval

We received ethical approval from the Committee for Human Research at the University of California, San Francisco and from the Universidad del Valle de Guatemala. Written informed consent was obtained from all study participants included in the study.

Results

Participants

Among 187 participants in the KAP survey, all but one was female, with a median age of 36 years (interquartile range, IQR: 28–48) and a median household size of five people (range: 2–13). Nearly three-quarters were indigenous (n=137) and had a primary school education or less (n=135). Among all respondents, 118 (63.1%) stated that the LPG stove was their primary stove. Among these, only 16 (13.5%) stated that they used LPG exclusively. Even though all households owned an LPG stove, 35 (18.7%) reported using an open fire and 33 (17.6%) using a *plancha* (wood-fired chimney stove) as the primary stove, with the LPG stove as a secondary stove. Only three (1.6%) used an electric stove as the primary stove. Eighty-five households (45%) stated that they did not use any open fires for cooking. Multiple stoves used in the same home, or stove stacking, was common. Most of the stove-stacking households purchased wood (n=113; 66%), in addition to gathering wood, at a median monthly cost of 120 *quetzales* (IQR: 60–250), or US\$16.00/month. The median monthly cost for LPG fuel was 90 *quetzales* (IQR: 80–100), or US\$12.00/month. Among all stove-stacking households that participated in the stove use monitoring study, gas stoves

were used a median of 8.5 hours per week (49% of cooking time), with differences based on indicated primary stove (Table 2).

Theme 1: The “new technology” should be framed in terms of what the old technology lacks—New cookstoves can bring significant benefits, however elders may perceive them as disruptive since they may perceive older wood-fired stoves to be adequate:

“... my daughter insisted on buying a gas stove after I got ill... with a gas stove she prepares her own breakfast, but I only use it for re-heating. I'm too old (she laughs)...sometimes the matches don't light and you hear 'shhhhh' (onomatopoeia) from the gas, so I get afraid it will explode. With the plancha you know the fire is on or off” -LPG Focus Group

Trade-offs between wood and LPG stoves

Individuals showed an awareness of the ‘primary benefits’ of a stove’s utility (Figure 1). These perceptions influenced opinions about which stove is more convenient. For both open fire and *plancha* stoves, perceived control over the cooking process was important. From interviews and focus groups, we heard: “*the plancha takes time to light, but food cooks faster when the fire is lit*”; “*the open fire tarnishes pots, but bigger pots can be used*”; and “*walls and clothes get stained, but the open fire gives off warmth*”.

Participants discussed inconveniences and benefits of the *plancha* compared to the LPG stove: “*it may be difficult to clean, but it is cheaper to maintain or repair than an LPG stove*”; “*it may take time to heat up, but it retains cooking heat for a long period of time* “. These trade-offs demonstrate a logic across a spectrum of advantages and disadvantages of different stoves. Food taste, cooking times and ease of use are all critical elements that a new stove must fulfill to displace the old one.

The “new technology”: Reasons for using LPG

Some women decided to purchase a stove based on a family member’s illness:

“My child suffered constantly from cough and chest pain... The doctor told me that he has asthma ‘because of smoke’. So when I was cooking I tried to put him far away from the smoke. A year later we moved, because the house didn't belong to us. Now we have a kitchen and a gas stove.” --LPG Focus Group

While 19 (10.2%) of KAP survey respondents discussed that the reason for acquiring an LPG stove was for “health reasons”, more common reasons were because they heard it was “fast” (25.1%), “easy” (16.6%), or because family members worked outside the home (15.0%) and saw the advantages of using a gas stove at their place of employment or needed food prepared quickly before they left for work. Women perceived that their social status increased when they owned an LPG stove because there was less smoke in the home and their hands did not get sooty. Women stated “*my kitchen looks better*”, “*it's nice to have a clean house*”, “*my clothes are not stained with soot*” or “*I don't smell like smoke*”. Respondents discussed advantages and disadvantages in continuing to use a gas stove; the top three advantages of a gas stove were fast cooking (53%), doesn't create smoke (32%) and cooking processes can be controlled (14%) (Figure 1). One woman stated, “*It's more*

practical. In the time that it takes me to cook, I can sweep, mop, wash dishes, all without worrying that the flame will go out.” When asked about the disadvantages of the LPG stove, 9% stated that they couldn’t think of one disadvantage, which is notable in that all women were able to state a disadvantage of the open fire or the *plancha* stove.

Theme 2: Income is not a predictor of gas stove acquisition, but may predict sustained use—Thirty-three (17.6%) women stated that their LPG stove was a gift from parents, children or their spouse. Special occasions, such as weddings, birthdays or Mother’s Day were reasons for receiving a gas stove. Twenty-seven women (14.4%) stated that they purchased a gas stove because they did not have space for a wood stove. Households did not necessarily prioritize the purchase of LPG stoves over other household items. During household observations in homes using woodstoves we noticed that other goods, such as flat screen televisions, “smart” phones and stereos, appeared to be more aspirational than acquiring a gas stove.

Findings from qualitative interviews showed that discretionary household income and affordable gas were determinants of LPG stove use. Expectations about stable gas prices and dependable income played a central role. Men cited high cost as a primary reason for not using LPG stoves consistently:

“... families are poor. People don’t always have money for gas...I gather wood from our land, so I don’t buy wood. Repairing a gas stove is not worth it, it would cost as much for a new one, so I told her to keep using it until it’s completely broken” - Men’s Focus Group

However, in the KAP survey, higher-income households did not seem to prioritize the use of LPG. Households with higher median incomes or willingness to pay more for fuel used wood- fueled stoves (both improved chimney stoves, or *planchas* and open fires) more hours per day, but did not increase gas stove use, compared to those households below the median (Table 3).

Theme 3: Men are key decision-makers but messages about LPG use are not targeting them—In the KAP survey, 52 women (28%) indicated that their male partner was the primary decision maker about new household purchases, while 95 (51%) stated that the decision was shared. Women are often provided with a weekly allowance for food purchases, but they don’t have the financial independence to make decisions about gas refills.

*“our husbands give us limited household expenses. If the gas finishes sooner [than expected], then we use wood; that’s why it’s necessary to have a *planchita* or a place you can make a fire. If things get more expensive [husbands] don’t give you more money, you still need to save money”*— Wood and Gas Focus Group

Decisions concerning cooking practices are influenced by gender dynamics, and males regularly make decisions about household investments, including fuel procurement. Due to gendered disparities in cooking activities, some men appeared indifferent about the benefits of LPG, stating, “women are accustomed to smoke while cooking”, “women prefer to cook with wood”, or “smoke is not necessarily a cause of illnesses. “However, men stated that

gas stoves improve their quality of life because food is prepared promptly before they leave for work or after they come home.

Theme 4: When stoves are viewed as “prize possessions “ they are protected and may not be used—Stoves are not merely material objects; they hold symbolic value as prized possessions.

“That’s the good thing with this stove, you can take it anywhere you like and it looks nice” --LPG user, in-depth interview

When young couples decide to move from their parent’s house, stove ownership becomes important.

“Last year I got married and my mother feared I would take the gas stove with me, but I didn’t want a used stove. I wanted a new, fancier, bigger one!”--LPG user, in-depth interview

Paradoxically, the value of the gas stove deterred some users, especially new users, from exclusively using the stove, for fear of ‘damaging’ it. Women who bought stoves on credit were afraid to use the stove because it was “bank property”. During household observations, poorer households placed the stove in a ‘special space’. Women were concerned about food spills on the LPG stove since they perceived that burners deteriorate rapidly, decreasing stove functionality.

“I was afraid of using my first gas stove because it was so precious.so I just didn’t want to use it every day, until one day it didn’t work”-- LPG user, in-depth interview

Theme 5: Collective fear about stoves is not based on personal experience, but on “stories women have heard”—When we asked LPG owners in KAP survey, “What are some reasons that other people continue to use open fires or *plancha* stoves”, 33 (18%) stated that LPG is dangerous. Cylinder explosions, gas leaks, and burners that are inadvertently left on but not lit were cited reasons. Fears were a combination of rare personal experiences and more common sensationalistic news stories with frightening outcomes that illustrate the uncertainties of safe LPG use.

“-.that’s why I’m afraid of [gas] stoves. I always think I left the knobs open, or that the children will turn the knobs on and cause an explosion.

-One day that happened to me: I thought I had turned the knob off, but I didn’t. The next morning, I smelled gas. Thank God the kitchen is not near the bedroom--can you imagine if someone lit a match?!” --LPG Focus Group

The few focus groups interviewees who had experienced an adverse event reported taking more precautionary measures than those who had never experienced a problem. They reported covering their cylinder regulators with damp cloths, even though this technique does not prevent gas leaks. Additionally, women were concerned that children would play with stove knobs and inadvertently turn the gas on.

“-I have little children and they are naughty, they touch everything, that’s why I’m afraid of using a gas stove.

-But it’s not only dangerous when you have little children. Sometimes the gas leaks, that’s why I put a cloth over the cylinder.

-I also do that, but sometimes it is not the cylinder but the hose. You should always have in your mind that a gas stove is dangerous” --LPG Focus Group

Theme 6: Sustained LPG use is hampered by two major factors: seasonally available wood and LPG retailers who are perceived as dishonest—

The two most common factors that emerged from qualitative and KAP surveys demonstrated the trade-offs between fuel choice were access to free wood and lack of trust in LPG distributors. While free wood encourages sustained use of the wood stove, undependable LPG distributors discourages sustained use of the LPG stove. These are thus inextricably linked in household decisions about fuel use.

Wood access

Farmland ownership and local coffee farming, the supply of local firewood is seasonally available and often free. Some fuel retailers sell firewood and also refill LPG cylinders, thus influencing consumption of both fuels.

“sometimes during the rainy season it’s difficult to find dry wood. But there are people who sell firewood the whole year, they come by in big trucks. They buy a lot of firewood at the coffee plantations and sell it...” --Wood user, in-depth interview

In our KAP survey, respondents stated that people continue to use *planchas* because firewood is free and easily accessible (26%). Gathering little tree branches was frequently mentioned.

“when you walk near plantations there are big branches that you can reach from the outside, so even if it’s not much you can always get wood” --Wood Focus Group

Buying wood, even if more expensive in the long-term, is more accessible in the short-term. Women saved small amounts of their weekly allowance to purchase small amounts of wood. A major barrier to increased uptake and use of LPG was fuel cost. Many families had to “wait it out” when prices went up, using gas when they had steady income:

“I rarely use the plancha because we can afford gas. Gas isn’t too expensive now and I’m working...But if we can’t afford gas, we’ll have to use wood again”-- LPG user, in-depth interview

Using stove use monitoring data, we explored stove use based on collected or purchased wood, and by season (Table 4). Those who purchased wood used wood and gas stoves nearly equally. While 24 (12.8%) of KAP participants stated that the rainy season, when wood is wet, is a time to use the LPG stove, we found little difference in gas stove use based on season. Taken together, these findings indicate that the decision to use gas and wood stoves is more nuanced than just availability of free or reduced cost wood.

LPG stove and fuel retailers

There are approximately seven LPG stove retailers in the area. Stove retailers attract ‘regular customers’ with demand based on LPG price fluctuations, which ranged between US\$9.93 and US\$11.92 for a 25-pound cylinder during the study period. All fuel retailers mentioned difficulties in cylinder distribution due to lack of national price policies, non-transparent pricing from the LPG industry, and the negative effect of price variability on consumer sales. Some small businesses complained of “unfair competition”, like spreading negative rumors about a business. Consequently, competition is strong between LPG fuel distributors to ensure steady streams of faithful clientele. Participants mentioned product quality, transparent payment plans, fair credit, flexible distribution hours, and excellent service as of utmost value. When choosing an LPG fuel retailer, focus group users wanted the LPG cylinder to weigh precisely 25-pounds and do not want dented, leaking cylinders.

“I have three gas distributors in town but some sell bad cylinders. I have a scale here at my business to check the cylinder weight, but sometimes [the problem] is connecting hoses, the valves or the cylinder installation, so you have to make sure that everything is okay because if isn’t, people won’t trust my product anymore.” -- LPG stove retailer

There is distrust among local LPG retailers who complained that other LPG suppliers only partially fill the tanks, do not maintain the tanks, and do not provide adequate safety training. Distrust in others influences LPG tank distribution, reducing distribution efficiency and increased operational costs.

Theme 7: Wood fuel collection is seen as a time to enjoy the company offriends and family and is not “drudgery”—Wood collection is time consuming, but is it “women’s drudgery”? In our study, many women referred to wood collection as an enjoyable activity, a time to chat with friends or take walks outside.

“In my case, going out to gather some branches is relaxing because I can spend a few hours outside. What is tiresome is being always at home cleaning and cooking!” -- Wood and Gas Focus Group

“But going out to get some firewood is not a problem. I like to go out with my neighbor so we can chat (she laughs)” --Wood Focus Group

When the amount of wood collected exceeds personal needs, wood is used as capital, and women sell or trade wood for other goods. Many women perceived wood collection as an important source of additional income.

Discussion

In Guatemala, fully displacing traditional woodstoves is a considerable challenge, especially for the poorest of poor, who continue to use deteriorating stoves and struggle to pay for fuel. While the consistent use of LPG stoves will undoubtedly reduce HAP, understanding what matters most to people when they choose a specific stove or fuel is essential for sustained use. Mistaking the unavailability and/or inaccessibility of LPG stoves as the sole problems to be solved preempts the idea that other barriers may be more important. Strategies to

introduce new technologies need to reflect people's perceptions about how their current stove already meets their needs (Lewis and Pattanayak 2012, Rehfuess et al. 2014). Changing cooking practices to cleaner fuels will not be achieved entirely by reinforcing ideas of 'reducing health risk', but through perceived efficacy and convenience of the LPG stove.

Cookstove programs typically focus on women as the primary recipient, rather than on the benefits to family or community. Finding innovative methods to include men in promotion of clean cookstoves should be a priority. In the KAP survey, a quarter of household decisions are made only by men, but half are made jointly. Men did not prioritize LPG fuel purchases or stove repairs. Men are household decision-makers and yet many minimize health problems associated with wood smoke; these men should be included in clean cookstove campaigns. Some spouses purchase stoves for their wives on Mother's Day, fathers purchase stoves for their daughters when they are married; these events could be used to promote LPG stoves. Encouraging men to provide women with money to purchase gas fuel might enable LPG cylinder refills instead of substitution with wood.

LPG stoves were purchased because family members, usually children or spouses, work outside the home. Engaging with workplaces to incentivize the use of LPG is one way to increase adoption. Messages that appeal to men, and increasingly women, who work outside of the home should focus on the speed and ease of gas stoves. Cooking demonstrations at health fairs and community events may successfully demonstrate the time-savings advantages of clean cookstoves (Person et al. 2012, Goodwin et al. 2015, Namagembe et al. 2015)

As others have found (Thurber et al. 2013), we also found that few participants decided to purchase LPG stoves because they thought smoke was harmful. If the goal of promoting LPG use is to reduce respiratory illnesses, other potential hazards, like accidents or explosions, need to be addressed. Although behavior change interventions often focus on rational behaviors, emotions such as fear lead to irrational behaviors that are challenging to address. In Guatemala, LPG companies have created colorful instruction pamphlets about gas safety to address these common fears. Governmental authorities should provide free pamphlets, as well as inspection of cylinders to make the customers more confident about LPG use. Gas retailers should demonstrate safe cylinder installation and assist families to detect and respond to gas leaks. This would improve compliance and reduce collective fear. Other key messages should promote the "cleanliness" of the gas stove.

Contrary to what others have found (WHO 2006, Mortimer et al. 2012), women in our study stated that fuel collection was a time to enjoy friends and family. Collected wood was an income source. While carrying heavy loads of wood and walking long distances has negative physical impacts (Matinga et al. 2013), the view that this is "drudgery" may be an outsider's view. Promotional messages to encourage LPG use might emphasize that women will still be able to collect wood when they want to and women will have more time to do so when they cook with LPG.

“improved” wood stoves to 100,000 woodstoves by 2032 (Minas 2017a). There is no mention of alternative clean cooking technologies, such as gas. In this context, developing markets for affordable, accessible LPG needs to be prioritized. These steps were outlined in 2014 document (Cookstoves 2014), but substantial work remains to be done. Sustained, transparent partnerships between gas industries, government energy ministries, NGOs, and academia must be strengthened (Smith 2015). Strategies to generate demand for LPG stoves, to strengthen supply-chain of LPG in marginal urban and rural areas, and to develop regulatory mechanisms to ensure safe use of LPG are essential. At the distributor level, vendors should be trained to provide not only well- functioning cylinders, but to educate household members to recognize leaks and other safety tips when they deliver cylinders to the home. At the household level, information about consumer safety and health awareness should involve men, as well as women.

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Open Fire	
Advantages	Disadvantages
<ul style="list-style-type: none"> • More than one pot can be used at a time (26%) • Food can be cooked faster (21%) • Saves money (17%) • Can put heavy pots on the open fire (11%) • Can use <i>comal</i> (separate flat griddle) to cook tortillas (8%) • Heats home better during winter (5%) • Can leave pots on fire without worrying (4%) • Food has better flavor (4%) • Food remains warmer longer (4%) 	<ul style="list-style-type: none"> • Smoke pollutes the air (79%) • Risk of burns/fires (22%) • Uses too much wood (13%) • Blackens pots and kitchen walls (12%) • Takes time to light the fire (9%) • Harms lungs, throat, and eyes (8%) • Sometimes there is no dry wood to use (5%)
Plancha chimney-stove	
Advantages	Disadvantages
<ul style="list-style-type: none"> • No smoke in kitchen (67%) • Uses less wood (34%) • Can cook different foods on it (25%) • Less chance of burns or injuries (9%) • Keeps pots and kitchen clean; hygienic (5%) • Food cooks fast (4%) • Tortillas can be prepared on it (4%) • Saves money (4%) • Can leave food on stove without worrying (3%) • Retains heat (2%) 	<ul style="list-style-type: none"> • Expensive to maintain or repair if ruined (16%) • Cooks slower than the open fire (14%) • Makes bad tortillas (11%) • Hard to use (10%) • Need to have patience when cooking (7%) • Not big enough (6%) • Difficult to clean the chimney (5%) • Can't put heavy pots on it (4%)
Liquefied petroleum gas stove	
Advantages	Disadvantages
<ul style="list-style-type: none"> • Fast cooking time; don't have to wait (53%) • No smoke (32%) • Can control cooking process/ level of flame (14%) • Specific foods and drinks (e.g. eggs, rice, coffee) • Practical and easy (7%) • Clean kitchen (7%) • Don't have to blow on flame to start fire (6%) • More burners, cook many foods at different temperatures (5%) • Can do other tasks; clean or care for children (4%) • Not so hot in kitchen (6%) • Health reasons (2%) 	<ul style="list-style-type: none"> • Gas runs out, sometimes in middle of cooking; unpredictable when gas will run out (33%) • Beans need time to cook, too much gas (28%) • Other foods use too much gas (corn, meat) (16%) • Slow, low flames on smaller stoves (6%) • Gas leaks smell bad; afraid of stove (6%) • Can't make tortillas on gas (5%) • Food doesn't have same flavor as wood (5%) • Food/drinks boil over, spilling onto stove (5%) • Burns food if not paying attention (4%) • Spills and splattered grease, cleaning stove (4%) • Can't cook with clay pots (2%) • Can't cook large pots of food (2%) • Food gets cold faster after cooking (2%) • Likes the stove, no complaints (9%)

Figure 1.

Advantages and disadvantages of two primary wood fuel stoves, open fires and the *plancha*, drawn from KAP surveys of 187 homes.

Table 1.

Methods used in study

	Number of Participants	Method for data analysis	Knowledge to be gained
Knowledge, Attitudes, and Practices survey	187	questionnaires; quantitative analysis using descriptive statistics	demographic information; food preparation; gas stove use; gas stove acceptance; wood stove use; costs; health and well-being
Focus Groups (n=7) 2 focus groups with wood stove only	11	open-ended focus group guides; qualitative thematic analysis of coded transcripts	cooking practices; general perceptions of LPG; practices related to food preparation; issues related to health; fuel consumption and use
2 focus groups with wood and gas users	12		
2 focus groups with gas users	18		
1 focus groups with men only	6		
Individual Interviews with community members	33	semi-structured in-depth interviews; qualitative thematic analysis of coded transcripts	interviews building on KAP survey; cooking processes; perceptions of the different types of stoves; fuel collection; and impacts on health and well-being; interviews with community leaders about other stove programs, credit and costs
Observations	10	in-home participant observations	food preparation; gathering wood
Stove Use Monitoring Gas stove users	62	quantitative, using temperature sensors on stoves	stove adoption and sustained use in new LPG users and in long-term users

Table 2.

Stove use monitoring (SUMS) based on primary stove type (N=measurement rounds; n=stoves monitored)

	Overall N=177	Primary stove identified in stove stacking households	
		Wood stove N=34	Gas stove N=43
<i>Plancha</i> use (hours/week), median (IQR)	14.1 (10.1–16.7) n=74	14.9 (9.6–16.7) n=16	12.4 (9.6–16.7) n=21
Open Fire use (hours/week), median (IQR)	6.3 (4.6–8.6) n=125	5.3 (2.7–6.8) n=22	5.7 (4.1–7.6) n=25
Gas stove use (hours/week), median (IQR)	8.5 (6.4–11.5)	6.4 (2.7–8.3)	10.4 (8.6–14.6)*
% of total cooking time using gas stove ^a , median (IQR)	49 (34–62)	41 (23–52)	54 (41–66)
Participants compliant with gas stove ^b , % (n)	15% (26)	12% (4)	26% (11)

^a Calculated as the median of the individual households' % of total cooking times across all households over all rounds

^b Defined as 14 hours of gas stove use per week

[§] $p < 0.005$ by generalized estimated equations

Table 3.

Stove use monitoring (SUMS) based on median income (n=measurement rounds)

	Below median per capita income n=73	Above median per capita income n=77	Can pay below median fuel cost n=56	Can pay above median fuel cost n=50
<i>Plancha</i> use (hours/week), median (IQR)	11.9 (9.2–15.1) n=33	15.2 (13.6–16.9) n=27	14.1 (12.9–16.7) n=16	14.7 (10.6–16.8) n=28
Open Fire use (hours/week), median (IQR)	6.0 (4.5–8.2) n=47	6.7 (4.5–8.6) n=64	6.0 (4.2–7.3) n=44	6.6 (5.0–9.4) n=29
Gas stove use (hours/week), median (IQR)	8.7 (6.9–12.7)	8.5 (6.5–10.3)	8.1 (6.3–10.2)	7.6 (5.2–10.9)
% of total cooking time using gas stove ^a , median (IQR)	52 (41–65)	52 (34–61)	54 (37–59)	43 (33–53)
Participants compliant with gas stove ^b , % (n)	19% (14)	9% (7)	13% (7)	16% (8)

^aCalculated as the median of the individual households % of total cooking times across all households over all rounds^bDefined as 14 hours of gas stove use per week

Table 4.

Stove use monitoring (SUMS) based on wood collected or purchased and by season (n = measurement rounds)

	Does not Buy wood [n=49]	Buys wood [n=127]	Does not collect wood (n=113)	Collects wood (n=63)	Season		No Harvest (n=129)	Harvest (n=48)
					Rainy (n=84)	Dry (n=73)		
<i>Plancha</i> use (hours/week), median (IQR)	13.8 (9.3–16.7) n=16	14.4 (10.8–16.5) n=58	13.5 (10.4–16.2) n=52	14.9 (9.3–16.8) n=22	13.3 (11.1–15.8) n=36	14.7 (10.0–16.8) n=28	13.5 (9.9–15.9) n=57	15.5 (11.9–17.1) n=17
Open Fire use (hours/week), median (IQR)	6.3 (4.1–9.4)	6.2 (4.7–8.1)	5.5 (4.5–7.2) n=69	6.8 (5.1–9.6) n=55	6.9 (4.9–10.0) n=62	5.5 (4.0–7.5) n=51	6.3 (4.5–8.6) n=89	6.4 (5.0–9.0) n=36
Gas stove use (hours/week), median (IQR)	7.8 (6.1–11.5)	8.6 (6.4–11.5)	8.6 (6.3–11.7)	7.9 (6.6–11.1)	8.1 (6.4–10.8)	8.6 (6.2–11.5)	8.5 (6.2–11.5)	8.8 (6.9–12.1)
% of total cooking time using gas stove ^a , median (IQR)	48 (28–66)	49 (36–60)	50 (37–60)	47 (30–65)	49 (36–66)	51 (34–71)	48 (30–64)	49 (28–61)
Participants compliant with gas stove b, % (n)	14% (7)	15% (19)	16% (18)	13% (8)	17% (14)	15% (11)	16% (20)	13% (6) [§]

^aCalculated as the median of the individual households' % of total cooking times across all households over all rounds^bDefined as 14 hours of gas stove use per week[§]p=0.08