

# Adoption of LPG for cooking in two rural communities of Chiapas, Mexico

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## ABSTRACT

In 2011, a government initiative provided Liquefied Petroleum Gas (LPG) stoves and cylinders to almost 1000 rural families in Chiapas, Mexico. In 2017, the Pan-American Health Organization (PAHO) conducted an evaluation of cooking practices among the beneficiaries of these stoves.

Although almost 100% of households continue to use firewood for cooking, they cook an average of 58% of their food with LPG. Of the families that used to rely exclusively on firewood before 2011, 32% have now started to use LPG. Primary cooks—almost entirely women—recognize the advantages of cooking with LPG and the health Problems associated with firewood use, with the primary barrier to using LPG being its high cost. Women spend 35–65 h a month preparing tortillas—the main food cooked with firewood. The alternative store-bought tortillas are up to three times costlier.

When given the opportunity to cook with LPG, families recognize its advantages and are incentivized to continue using it, despite its cost. The higher the socioeconomic status, the higher LPG use is. The authors suggest that subsidizing tortilla production could facilitate the exclusive use of LPG, avoiding the negative health impacts of firewood use and saving more than 25% of women's productive time.

## 1. Introduction

The Sustainable Development Goals (SDGs) include ensuring universal access to affordable, reliable and modern energy services by 2030 (SDG 7. UN, 2015). This access is understood not only as the installed capacity or closeness to a network or supply chain, but as the population's real possibility of consuming this energy through rates that consider the purchasing power of the less privileged. Globally, more than 1.3 billion people lack access to electricity and more than 2.8 billion use solid fuels like firewood and charcoal for cooking and heating (WHO, 2016). Solid fuel use (SFU) is a public health concern in the context of traditional cooking in an open fire that leads to incomplete combustion and substantial air pollution exposure. Exposure to the resulting air pollution is one of the world's greatest environmental health risks, estimated in 2012 to lead to 3.8 million annual premature deaths (Lim et al., 2012).

Mexico is an upper middle-income country (World Bank, 2018), with a GDP (Gross Domestic Product) per capita of USD 12,448 (similar to Panama and Uruguay, lower than Argentina and Chile). It is a highly urbanized country, with 79% of the population living in urban areas. More than 98% of households have access to electricity and 90% have access<sup>1</sup> to LPG (OLADE, 2017). However, almost 19 million people

(15% of the population) live in households that use solid fuels, mainly for cooking. Most of this SFU occurs in rural areas, but 7% of users live in urban households. The World Health Organization (WHO) estimated more than 15,600 deaths in Mexico in 2016 because of exposure to fine particulate matter (PM<sub>2.5</sub>) produced by the incomplete combustion of firewood in inefficient stoves (WHO, 2018).

The combined use of firewood and LPG for cooking is common and varies between regions (INEGI, 2010; Troncoso et al., 2007; Masera et al., 2005). According to data from the National Institute of Statistics and Geography (INEGI, 2010), 58% of households in Chiapas used firewood to meet their cooking and heating needs. Chiapas has a Human Development Index (HDI) of 0.66 (the country's is 0.76), and 19% of its population is indigenous.

In 2011, the Government of Chiapas developed two new towns, Ciudad Rural de Ixhuitán (IXH) and Ciudad Rural de Jaltenango (JAL), to house almost 1000 displaced families due to risk of flooding in their 14 and 15 original rural communities, respectively. The families relocated to IXH came from the following locations: El Aguacate, Loma de Caballo, Monte Chico, El Tulipán, El Zapote, La Asunción, Monte de Oro, El Caracolar, El Cacaté, El Mirador, Nueva Esperanza, Las Palmas, San Felipe and San Antonio. The families relocated to JAL came from Nueva Colombia, Nueva Independencia, Nueva Palestina, Plan de

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<sup>1</sup> Considered only as supply and not necessarily as use.



Fig. 1. Examples of abandoned biomass stoves.

Ayutla, Querétaro, Salvador Urbina, Siete de Octubre, Santa Rita, Barrio el 9, Jerusalén, Piedra Blanca, Plan de la Libertad, Nueva Alemania and 20 de Noviembre. The homes, 610 in JAL and 378 in IXH, were built based on a Healthy Housing Model promoted by the Pan American Health Organization (PAHO) in Mexico. All houses provided by the government contained a pre-installed two-burner LPG stove and one full 20 kg LPG cylinder. In IXH, all households also received in 2014 in-situ-built biomass stoves with chimneys through a municipal program not linked to the initial housing project, providing a quasi-experimental site to study community and family driving forces for the adoption of cooking technologies in Chiapas.

In 2017, upon request from the national authorities, PAHO conducted an evaluation of cooking practices among the beneficiaries of these LPG stoves. By the time this study was carried out, none of the biomass stoves with chimney given in 2014 were in working condition (see Fig. 1), nor were any of the gas stoves that were delivered in 2011.

Multiple studies have evaluated adoption and use of improved cookstoves in Mexico (Catalán-Vázquez et al., 2018; Calderón A. et al., 2018; García-Frapolli et al., 2011; Orozco-Hernández et al., 2012; Pine et al., 2011; Ruiz-Mercado et al., 2011; Ruiz-Mercado and Masera, 2015; Serrano-Medrano et al., 2018; Troncoso et al., 2007; Troncoso et al., 2011); however, no study has followed firewood users' uptake of LPG stoves from a government initiative in Mexico. Through a mixed methodology (quantitative and qualitative), this study assesses cooking technologies and fuels used in IXH and JAL to evaluate the impact of the provision of an LPG stove and full cylinder to each household on the cooking practices in those communities and discuss implications for public policy.

## 2. Methodology

### 2.1. Research approach

This research employed a mixed methodology. Quantitative data was used to obtain socioeconomic indicators, estimate cooking times, cooking practices and fuel collection/purchasing in a random sample through statistical analysis; and qualitative research allowed us to register and analyze the perspectives of those involved in the cooking process in order to understand social dynamics from the perspectives of different stakeholders (Denzin and Lincoln, 2000).

A survey<sup>2</sup> was conducted in February 2017 in the communities of JAL and IXH, consisting of three sections:

- 10 questions to assess the socioeconomic status of families, based on the Poverty Probability Index (PPI) methodology proposed for

Mexico

- 16 questions developed to explore stove and fuel use and the level of satisfaction
- 16 questions from the WHO Household Energy Use Survey that assesses fuel and technology use, time spent by activity and health perceptions.

The PPI questions estimate the probability that a household has an income below a given poverty line, and they have been extensively used in Mexico. This methodology defines the questions that best represent the variables associated with poverty and extreme poverty for each country. The rating (0–100) is based on the answers to 10 simple indicators extracted from the National Survey of Household Income and Expenditures (INEGI) of 2008. A household with a score of 100 has no members under the age of 18, the female head of household has a college degree or higher, two or more people earn an income, the household has ceramic floors, tap water, a blender, an electric iron, more than one TV and the family does not cook with firewood (PPI, 2008). The core WHO Household Energy Use Survey questions have previously been tested in Paraguay (Troncoso et al., 2018).

Two focus groups followed the application of the survey. Due to budget constraints, the focus groups were carried out only in JAL.

### 2.2. Data collection

The survey was first piloted in the community of La Esperanza (Municipality of Tuxtla Gutiérrez, Chiapas) and then revised. The final survey was answered by women from a sample of 190 randomly selected houses (106 in JAL and 84 in IXH). Households were selected by assigning each interviewer a section of the community and then selecting the third house that he/she encountered to apply the survey. If members of a household were unwilling or unable to participate, the next house was selected. Answers were circled from a list of possible answers, which was not provided to respondents, or written down verbatim.

The 190 survey results were transferred to a spreadsheet and cleaned of data collection errors (mainly incomplete or contradictory information). 177 surveys were kept for data analysis (100 from JAL and 77 from IXH).

The survey allowed for the identification of households with either exclusive use of firewood or almost exclusive use of LPG for cooking. In JAL, those households were then invited to participate in focus groups, to represent the extremes in the continuum of fuel and technology use. 15 women participated in the focus group of firewood users and four participated in the group of LPG users. Focus group topics included:

- Cooking practices
- Uses of traditional firewood stoves in the home, besides cooking
- Decision-making regarding type of stove and fuel used

<sup>2</sup> At [https://www.paho.org/hq/index.php?option=com\\_docman&view=download&slug=enuesta-vivienda-rural-saludable-uso-de-energia-en-el-hogar-2016&Itemid=](https://www.paho.org/hq/index.php?option=com_docman&view=download&slug=enuesta-vivienda-rural-saludable-uso-de-energia-en-el-hogar-2016&Itemid=).

**Table 1**  
Weights applied to the responses on fuels used for different cooking activities.

Activity / fuel use	Weight <sup>a</sup>
<b>Activity</b>	
Breakfast	15%
Lunch	25%
Dinner	15%
Tortillas	30%
Beans	15%
<b>Fuel use</b>	
Always one fuel	100%
Two fuels used equally	50%/50%
Two fuels, with one used sometimes	75%/25%
Two fuels, with one used rarely	90%/10%

<sup>a</sup> If a household did not carry out one or more of the activities (e.g. purchases tortillas), then the weights of the other activities were increased proportionally to reach 100%.

- Perceptions of health risks due to the use of solid fuels
- Perceptions related to the use of LPG
- Perception of advantages and disadvantages of each type of stove/fuel used.

**2.3. Data analysis**

Each component of the survey was analyzed using the appropriated methodology. The third section (based on the WHO Household Energy Use Survey) included questions on fuel use for the five main cooking activities in Chiapas, namely breakfast, lunch, dinner, tortilla making, and beans. The question was: “Which fuel do you use for cooking ...” and the possible answers for each type of fuel (firewood or LPG) were:

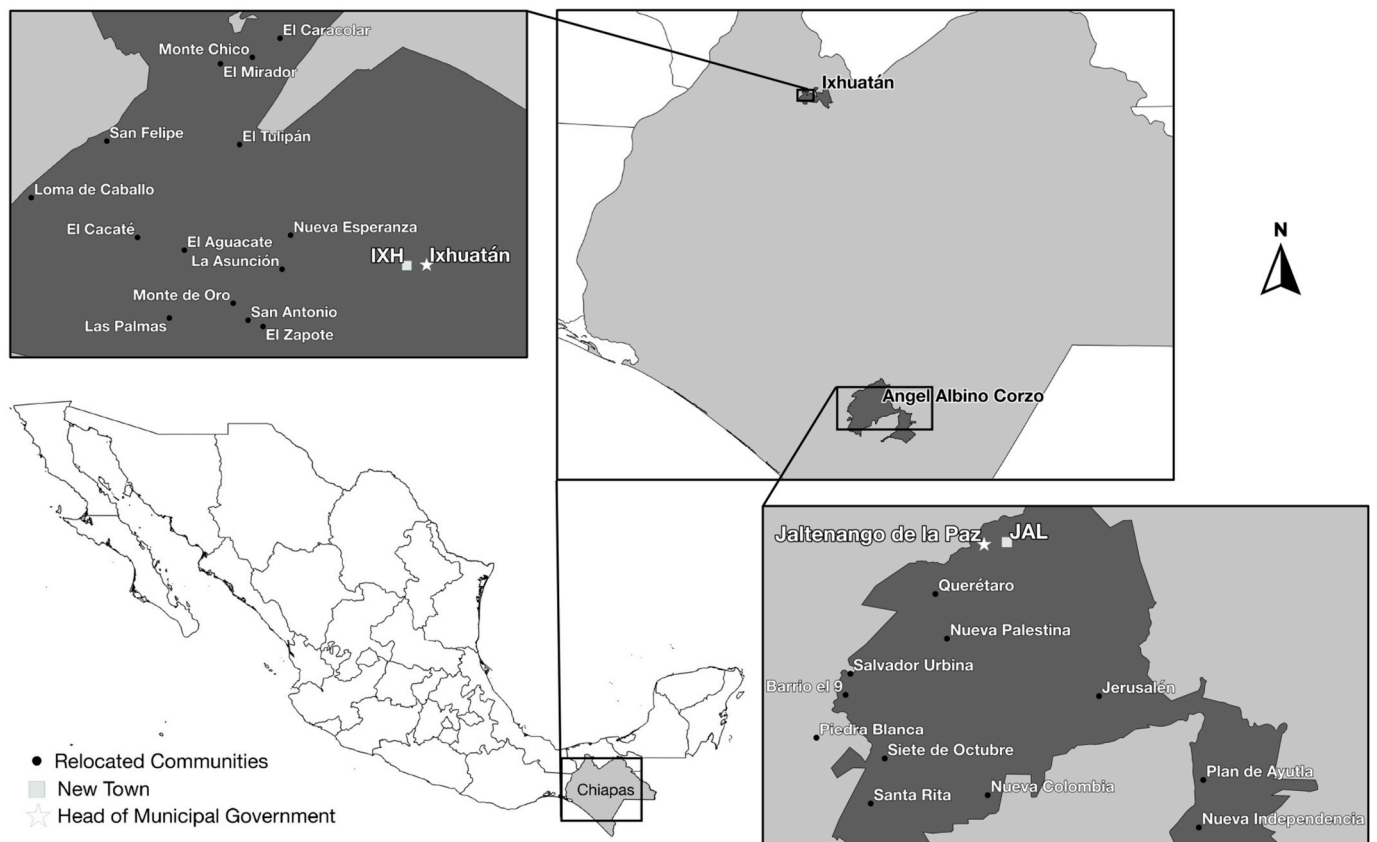
Always, sometimes, rarely. To estimate an overall fuel use index for each household, each cooking activity was assigned a different weight depending on their importance in terms of time and energy invested (Ruiz-Mercado and Masera, 2015). Likewise, weights were applied when an activity was performed with two different fuels. Table 1 shows the weights applied to the different cooking activities based on previous studies of cooking practices in Mexico (Troncoso et al., 2007; Ruiz-Mercado et al., 2011) and in cases of multiple fuel use for the same activity.

Descriptive statistics were calculated, and we performed Chi-squared tests for comparison of proportions and Z-tests for comparison of two means between communities. We also explored correlations between variables.

Focus groups were recorded and transcribed. Qualitative analysis of focus group data was done using the Atlas Ti 5.2 software, which encodes the ideas expressed and facilitates the analysis of recordings by themes to later create conceptual maps to further explore the relationships between different topics and the relative importance of each theme in the discourse.

**2.4. Study limitations**

We had assumed that all houses would have a functional LPG stove, since they were initially outfitted with one. However, we learnt that those stoves lasted no more than three months (according to some respondents and focus group members), and that all houses that still use LPG had to purchase another stove or use one they previously owned. A limitation of the survey is that it failed to ask whether households that do not use LPG do so because they no longer have a working stove. Although this question was not asked systematically in the survey, the topic was explored during focus group discussions, and 8 people reported it when answering the open question: “Why do you use firewood for cooking?”



**Fig. 2.** Location of JAL and IXH  
Source: The location of the IXH and JAL is based on IPCR, 2013a and IPCR, 2013b.

Focus groups were only conducted in JAL, so they should only be interpreted as representative of this community.

### 3. Results

#### 3.1. Context

Ciudad rural de Jaltenango (JAL) is in the municipality of Ángel Albino Corzo, Chiapas. Ciudad rural de Ixhuatán is in the municipality of Ixhuatán, Chiapas (see Fig. 2). Both new towns are located next to the towns that host the respective municipal governments (Jaltenango de la Paz and Ixhuatán). Although these towns brought together people from 29 different communities, all belonged to the same geographical region and share culinary customs. The distance between the new towns and their communities of origin is between 2 and 5 h<sup>1</sup> drive. The average annual temperature in both towns is above 25 °C and households do not require heating.

#### 3.2. Socioeconomic status

According to the PPI methodology for Mexico, 73% of respondents in JAL and 87% in IXH are living below the national poverty line, with 8% in JAL and 5% in IXH classified as extremely poor. From a maximum score of 100, the average score for respondents is 46.15 with a standard deviation  $s = 17.45$  in JAL, and 44.3 with  $s = 12.86$  in IXH. For comparison<sup>3</sup> purposes only, the sample was divided into five socioeconomic strata. The Very Low socioeconomic stratum was defined as those households with a score of 20 or less<sup>4</sup>; Low refers to those with a score between 20 and 40, inclusive; Medium to those who obtained between 40 and 60, inclusive; Medium-High to those who obtained between 60 and 80, inclusive; and High to households with a score above 80 points. The results are presented in Fig. 3. The majority of the households of IXH fit into the Medium socioeconomic stratum, and only 5% are classified as Medium-High, whereas the range of socioeconomic strata is greater in JAL. The difference between communities is significant ( $\text{Chi } p < 0.05$ ).

#### 3.3. Cooking practices and other uses of the stove

Almost all households reported using firewood to cook all or some of their meals. However, there are significant differences in the use of LPG before the intervention and after (see Table 2). Remarkably, many households that used only firewood in 2010 were using both fuels by 2017 (34% in JAL, 47% in IXH).

The amount of meals cooked with each fuel varies greatly between households. Fig. 4 shows the percentage of meals cooked with firewood by households in each community.

Households with 0–19% of meals cooked with firewood are households that usually do not make tortillas on a daily basis, and 86% are small families (see Table 3). Households that cook 80–99% of their meals with firewood are households that only use LPG to prepare coffee or re-heat food but prepare everything else using firewood.

Typically, the use of firewood is highly correlated with poverty, and JAL and IXH are no exceptions. Fig. 5 shows the distribution of households within each socioeconomic stratum, according to the percentage of meals cooked with firewood. Sixty % of households in the Very Low stratum cook more than 81% of their means with firewood, whereas households in the High stratum cook a maximum of 40% of meals with firewood. Table 3 presents family size compared to the

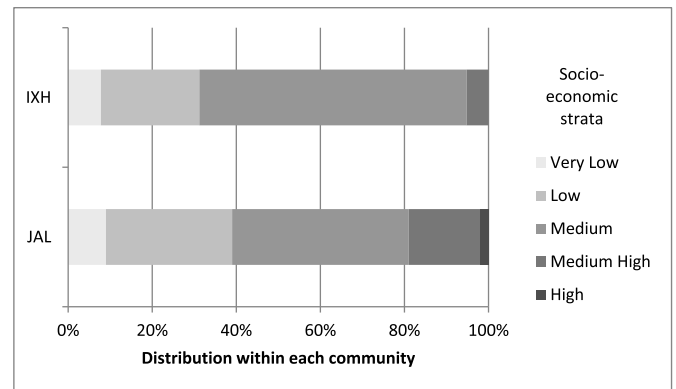


Fig. 3. Socioeconomic stratum by PPI of survey respondents in JAL and IXH.

Table 2

Fuels used before and after the relocation, by community (self-reported data).

Fuel used	JAL		IXH	
	2010	2017	2010	2017
LPG only	0	4%	0	1%
Firewood only	60%	22%	80%	32%
Firewood and LPG	40%	74%	20%	67%

In 2010 respondents lived in their original communities; 2017 is the year when the survey was applied, 6 years after moving to JAL/IXH.

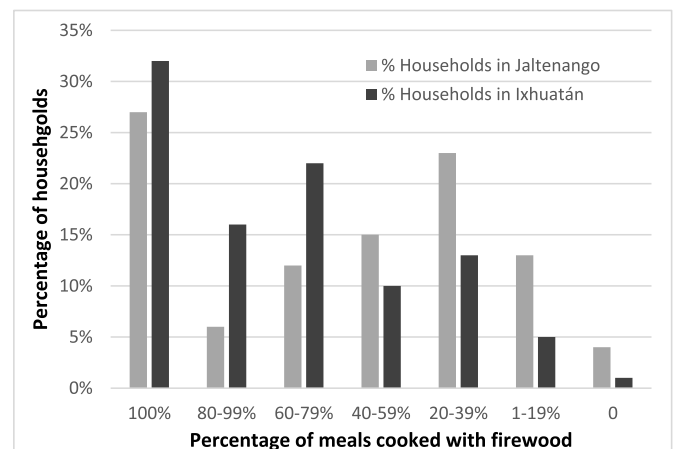


Fig. 4. Percentage of meals cooked with firewood per community.

percentage of meals cooked with firewood.

It can be observed that 60% of people in extreme poverty use only firewood for cooking, while 78% of people in the Medium-High socioeconomic stratum use LPG to cook more than 70% of their meals. On the other hand, households with larger families cook more meals with firewood than households with smaller families.

Households that buy firewood spend between MXN 150 and 600 (USD 8–32) per month on this fuel, whereas the cost of a 20-kg LPG cylinder is MXN 300 (USD 16). It is possible that some users already spend the same amount of money buying firewood as they would need to cook everything with LPG (around MXN 600/month).

The most important food for Mexicans is the tortilla, particularly in rural areas, and handmade tortillas are always cooked using firewood. This process can take between 35 to 65 h per month, depending on whether they make their own nixtamal or buy Maseca,<sup>5</sup> collect or buy

<sup>3</sup>This classification is only a reference indicator to help compare values within the sample, that is, a household can be classified as high socioeconomic level only with respect to other households in the same sample.

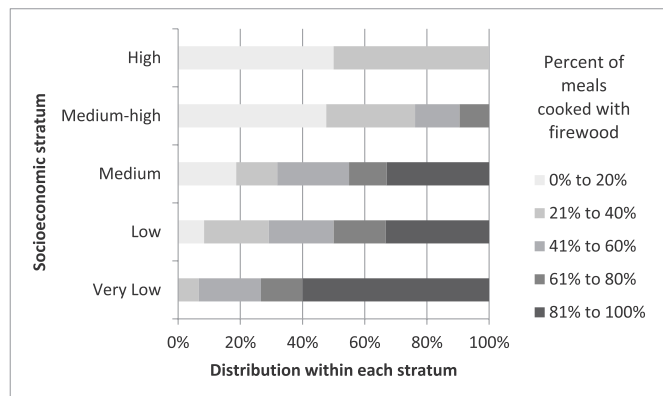
<sup>4</sup>The Progress out of Poverty Methodology places the line for rural extreme poverty in 22.9 using criteria from USAID (United States aid program).

<sup>5</sup>An industrialized tortilla flour mix that is ready to use after mixing with water.

**Table 3**  
Number of people per household and percentage of meals cooked with firewood.

# of people by household	# of households	0–20%	20–40%	40–60%	60–80%	80–100%
<b>4 or less</b>	86 (44%)	<b>26 (86%)‡</b>	15 (50%)	17 (46%)	10 (45%)	<b>18 (33%)†</b>
<b>5 or more</b>	91 (56%)	<b>6 (14%)†</b>	15 (50%)	20 (54%)	13 (56%)	<b>37 (67%)‡</b>

The outliers are shown in bold typeface (higher‡ or lower† than expected with 95% confidence).



**Fig. 5.** % of meals cooked with firewood and socioeconomic stratum in both communities.

their firewood, and the size of family. A regular home consisting of two adults and three children consumes around 4 kg per day. A detailed analysis, including the different options available for making tortillas and their cost, is shown on Table 4.

Considering that, in Mexico, the minimum daily wage is MXN 88.4 per day (USD 4.6, or MXN 11.05 per hour), making tortillas instead of buying them makes economic sense, even for those families that make their own nixtamal and collect their fuel. Purchasing tortillas from industrialized tortilla shops would need to cost 20–40% less than the current cost to be competitive—assuming that there is an opportunity cost and that women have a productive way of using their time and can obtain resources to pay for store-bought tortillas. Interestingly, making tortillas with Maseca and LPG is in the same price range as buying them; making tortillas with nixtamal and LPG is more expensive than buying them. That could explain why nobody makes tortillas using LPG cookstoves.

There are other household energy needs besides cooking that were included in the survey and that are shown on Table 5. These activities are mainly carried out using firewood and represent a significant use of energy. Any transition from firewood to cleaner fuels would need to consider these other uses and find sustainable solutions, such as solar water heaters, water filters and the mass-production of tortillas.

Different members of the household are involved in various aspects of firewood collection and use. Table 6 shows the time devoted to procuring and preparing firewood, cooking practices and decision making, disaggregated by household member and community.

Firewood stoves are used in average 28.4 h per week to cook (with  $s = 11.97$  h per week), and LPG stoves are used in average 12.2 h per week (with  $s = 7.34$  h/week). This difference is mainly due to the preparation of tortillas and nixtamal, which is traditionally carried out with firewood and takes in average 10 and 6 h per week, respectively.

When using firewood, the stove is reportedly kept lit for an additional period of 20.7 h per week, without being used to cook. Firewood stoves are therefore lit for a total of 49.1 h per week in average. The reasons provided by respondents were the long time required to heat the stove and the difficulty of turning it on and off. Women put large branches of wood that can burn throughout the day to avoid repeatedly igniting the fire or having to reheat the stove with each use.

All parameters vary between JAL and IXH. In order to evaluate if

differences in survey responses are significant, we performed CHI-squared tests for comparison of proportions and Z-tests for comparison of two means (with a 95% confidence interval). The results are presented on Table 7.

The clearest difference between the two communities is the level of satisfaction with firewood use. This is reflected by other variables such as the higher exclusive use of firewood in IXH, and lower use of LPG<sup>6</sup> when compared with JAL, fewer economic reasons not to use LPG, and stronger preference for using firewood—despite spending twice as much time collecting it. IXH seems to have developed as a more traditional community: Almost all households cook nixtamal, which is highly associated with firewood use, instead of buying ready-to-use Maseca flour. Furthermore, 30% of respondents in IXH indicated that it is the male head of household who decides which fuel to cook with, despite the fact that they are not involved in the cooking process. In JAL, 73% of the population buys all or part of their firewood (compared to 40% in IXH), which may explain the higher use of LPG in JAL since both cooking fuels require an economic expenditure. It is also worth noting that 54% of households in IXH cook with firewood inside a closed space, compared to 19% in JAL. This situation aggravates the risk of exposure to toxic fumes from incomplete combustion.

Considering that a 2014 program distributed “improved” cookstoves with chimney in IXH, it was interesting to find that there are more households with firewood stoves with chimney in JAL than in IXH (although the difference is not significant). During our field work, a community leader in IXH explained in an interview that the improved firewood cookstoves with chimney they received were very poor quality: the comal - a flat griddle traditionally used in Mexico - would not heat properly, and the built-in chimney lasted no longer than six months. This explains why those stoves were abandoned or dismantled (see Fig. 1).

The reasons for using firewood in both communities are shown on Table 8. Economic reasons are highly predominant and represent 75.7% of total responses in JAL and 52.5% in IXH. Cultural reasons were only 9% in JAL and 17% in IXH. Multiple answers were permitted.

### 3.4. Focus groups

The two focus groups of women had similar opinions regarding the advantages and disadvantages of using firewood and LPG. Therefore, the results are presented jointly, clarifying the type of user when relevant (exclusively firewood or mainly LPG). The data is presented using the participants’ own words and each quote in every section (in bold) is from a different woman.

#### 3.4.1. Reasons for using firewood

**It is more economical:** “I would like to have my normal, large LPG stove to put the maize, the beans, everything, but unfortunately we do not have resources. We do not want to be lighting fires because we have children who are ill with asthma, and even with just little smoke they are affected, and we do not have the means to take them to the clinic. Because of our poverty we have to use firewood, because if we had money to buy LPG we would do it. The husband does not generate, there is no movement of inflows and outflows of money, or jobs, that’s why people use firewood, even if they

<sup>6</sup> On average, 43% of meals were cooked with LPG in average in IXH instead of and 62% in JAL.

**Table 4**

Estimated costs of making tortillas vs. buying them considering different fuels and sources. All quantities consider a daily family consumption of 4 kg of tortillas (the average for these communities).

	Cost per unit <sup>a</sup> (MXN/kg)	Cost (MXN/month)	Time <sup>b</sup> (hr/month)	Cost of time <sup>c</sup> MXN/hr	Total cost per month
Tortilla shop (tortillería <sup>d</sup> )	14	1680	0		1680
Hand made with Maseca & purchased firewood	5.2	624	40	442	1064
Hand made with Maseca & LPG <sup>e</sup>	9.5	1140	40	442	1582
Hand made with Maseca & collected firewood	4.5	540	50	552	1092
Hand made with nixtamal <sup>f</sup> & purchased firewood	6	720	55	608	1328
Hand made with nixtamal & LPG	11	1320	55	608	1928
Hand made with nixtamal & collected firewood	5	600	65	718	1318

Cost in Mexican pesos (18 per 1 USD).

<sup>a</sup> Cost to produce 1 kg of tortillas (materials) plus cost of fuel to produce 1 kg of tortillas.

<sup>b</sup> Estimated time per month used in making tortillas plus time collecting firewood when collected (from focus groups).

<sup>c</sup> Value of time considering opportunity cost of the time needed to prepare tortillas considering a minimum daily wage of 88.4 MXN.

<sup>d</sup> A shop that prepares and sells machine-made tortillas. The price of 1 kg of tortillas was 14 pesos (0.75 USD) in March 2017.

<sup>e</sup> People reported that when they were cooking everything with LPG (first cylinder given for free) it lasted 15 days on average. Using the numbers on Table 1, we calculated the cost of cooking 1 kg of tortillas with LPG.

<sup>f</sup> Nixtamal is the name of the dough that is prepared to make tortillas. It is made by cooking maize with water, salt and lime.

get sick, and there are a lot of asthmatics because of the smoke.”

“It is easier for me to use firewood than to spend in gas, my husband brings me firewood from the ranch, a truck of firewood lasts 6, 7 months. If I cook maize, in one month the LPG is over, and it is 300 pesos, it is not convenient to buy LPG.”

“Now it is even easier, there are tortillerías, but there is no money, the tortillas are expensive, and we eat two kilos in the morning, two kilos in the afternoon, how much would it be? While with the Maseca I buy a kilo and a half for all day, at 12 pesos (0.67 USD) is the kilo of Maseca and yields for about two and a half kilos. When I do not make my nixtamal I buy my Maseca.”

“I would need to owe money to cook everything with LPG, because at least the nixtamal uses a lot of fire, the tortillas just the same. Yes, I have tried, sometimes when my husband goes to work at dawn I make my tortillas on the LPG stove to avoid going out in the dark, but it is one at a time and meanwhile, the gas is running out.”

**It is more suitable for making tortillas:** “You cannot make tortillas with LPG, because it is smaller, it fits just one tortilla in the LPG stove, as if we were playing, in the fire not, because we put our big comal and you can make three, four tortillas together.”

“If I was to use LPG I would need to buy tortillas because with the LPG it takes a lot of time, because making tortillas is slow and I would waste all the LPG.”

**It is faster to cook with firewood:** “I really prefer to cook with firewood, I love firewood, even if it hurts me, because it is fast, I make my breakfast, I put my maize, I put my tortillas and I already have everything going.” “In an open fire you can make a big fire, that’s when you can advance fast, when your fire is strong it cooks everything in one go. The LPG stove cannot fit many things at the same time, it is small.”

**Force of habit:** “Because all the people who are here in the countryside are used to living in the mountains, that in their fire they have a branch that lasts all day, and that branch is the one that serves for breakfast, food and dinner. When the poor people came here it was like feeling a punishment.”

**Table 5**

Other uses of domestic energy in both communities.

Use	Fuel used							
	JAL				IXH			
	Wood	LPG	Electricity	Sun	Wood	LPG	Electricity	Sun
Heating water for bathing	41%	5%	3%	3%	62%	4%	1%	
Boiling water for drinking	39%	10%			43%	10%		
Preparing food for animals	10%				6%			
Preparing nixtamal	78%				94%			

“We have always cooked with firewood, our mothers cooked with firewood.”

“It is very difficult to change those customs because they are already brought from the grandmother, from the mother. Although they have the amenities of the LPG stove, but it is very difficult to change from one moment to another.”

**Because of the flavor:** “The beans are cooked richer with firewood; with LPG the flavor is different.”

**Due to Problems with LPG distribution:** “The cylinder does not arrive full, and after 20 days it is finished—at the most one month. Seeing that sometimes it lasts two months, that’s when we realize that sometimes it is full and sometimes not.”

**Problems with the quality of the LPG stoves:** “Those stoves that were given together with the houses, talking about what is reality, they were for the garbage, burners burned. Nobody still has one of those stoves working.” “The thin tin with which they were made was undone and then quickly burned.” “Those stoves had no brand.”

#### 3.4.2. Disadvantages of cooking with firewood

**Access:** “We have to buy firewood because there is nowhere to collect it. We are afraid to go to the property of others to collect firewood.”

**Health:** “Smoke is bad for my health, the doctor already told me, I have a heart disease, but unfortunately, I have to use firewood.” “I suffer from my sight and the smoke hurts me.” “The smoke does not bother me because I already have a chimney, but the flame burns my arms, if money was not an issue, who would like to burn their hands in the fire of the stove?”

#### 3.4.3. Reasons to cook with LPG

**It is faster:** “I prefer a thousand times the LPG, because it is fast, for example, I arrive tired and I can cook some eggs on the stove. If I have to make a fire, if I have to wait until the comal is hot ...” “If I have money, I save it to buy my LPG, so that it helps me a little bit. As the children are in school, I have to get up early, I make my baby’s food quicker with LPG because it’s faster. If I do not have LPG I have to get up earlier, make my fire,

**Table 6**  
Cooking practices and firewood-related activities by household member.

Activity	JAL				IXH			
	Woman	Man	Boy	Girl	Woman	Man	Boy	Girl
Who collects the firewood? <sup>a</sup>	18%	54%	1%	1%	13%	70%		3%
Average number of hours per week collecting firewood	1.5	3.4	1	5	1.8	5.35		6
Who cuts the wood into small pieces? <sup>a</sup>	6%	32%		2%	9%	70%		
Average number of hours per week cutting firewood	3.8	2.8		2	1.8	2.1		
Who cooks?	96%	3%		1%	100%			
Average number of hours per week cooking	20.1	12.3		1	22.2			
Who decides what fuel use to cook? (in the remaining households, men and women decide jointly)	31%	16%	1% <sup>b</sup>	1% <sup>b</sup>	32%	30%		

<sup>a</sup> The totals are not always 100%.

<sup>b</sup> Adult daughter or adult son. Not all households collect or cut firewood.

**Table 7**  
Values obtained for each community and significance of the comparison at 95% confidence.

	JAL	IXH	Significant difference
<b>Firewood users</b>			
% exclusive firewood users	22	32	
% biomass stoves with chimney	35	29	
% households cooking with firewood in a closed space	19	54	✓
% households that use firewood to heat water for bathing	41	62	✓
% households that prepare nixtamal with firewood	78	94	✓
% users who collect firewood every 15 days or more	42	26	
% users who buy firewood every 15 days or more	31	50	
% firewood users who buy firewood daily	2	0	
% users who only buy firewood (never collect it)	50	18	
% households buying firewood	73	40	✓
Mean time per week collecting firewood (of those that collected)	2.9 h	5.2 h	✓
Average time the stove stays on daily	4.6 h	4.9 h	
<b>LPG users</b>			
Average time LPG stove is used every day (LPG users)	1.7 h	1.3 h	✓
% LPG-households that use LPG exclusively	4	1	
% LPG-households that use LPG only once or twice a day	48	57	
% users who use LPG to prepare more than 85% of all meals	16	9	
% households that switched from using firewood exclusively to using firewood and LPG	34	47	
% of meals cooked with LPG (only households that use LPG)	62	43	✓
% households that would not use LPG in any circumstance (don't like it)	2	4	
% households that would use LPG for everything if the cylinder cost was 3 USD instead of 18 USD	88	77	
<b>Decision making</b>			
% population below poverty line	73	87	✓
% households where the man decides what fuel to use to cook	16	30	✓
% households very satisfied with cooking with firewood	26	53	✓
% households that would prefer not to use firewood	14	8	
% households with economic reasons for not using LPG	70	51	✓
% households with cultural reasons for not using LPG	5	18	✓

Only those variables with more than 20% difference were included in the table.

**Table 8**  
Answers to the question: Why do you use firewood for cooking?

Reasons for using firewood for cooking		% JAL	% IXH
Reasons related to economic barriers	To save LPG	9	12
	LPG is very expensive	58	42
	Firewood is free or easy to collect	8	5
	There is no money to buy tortillas	6	12
	There is no other option	3	3
Reasons related to the time needed to cook with LPG	Food is prepared faster on an open fire	14	23
	Certain foods take a long time to cook with LPG	9	4
	You can cook many dishes at the same time on an open fire	1	0
Reasons related to characteristics of gas stoves	You cannot cook tortillas on an LPG stove	3	14
	Fire of an open fire is stronger than in an LPG stove	3	0
	Cooking with LPG is dangerous	0	1
Reasons related to preferences and customs	Flavor is better on an open fire	2	3
	It is our custom	0	12
	My family prefers foods cooked with wood	9	10

heat the food, make breakfast for my girl to go to school because she starts punctually at 8 a.m., but if I had my LPG ...” “And it always takes time to make the fire, it is not immediate. Once the open fire catches the fire, it cooks fast, but that time that is getting lost while the stove holds the fire, the pot could be heating up on the LPG stove, right?”

**It is practical:** “The LPG stove is easy to use, you just need to turn it on: It is more practical.”

**Because now there are tortillerías:** “Before in my village, I used firewood to make tortillas, but here I do not need to, because there is a tortillería.”

#### 3.4.4. Disadvantages of cooking with LPG

**Cost:** Buying firewood at retail price is considered expensive (one Mexican peso per piece), and participants indicated that they use between 10 and 25 pieces a day (depending on family size and cooking practices). It is cheaper to buy a truckload (MXN 500) which lasts at least two to three months, depending on family size. Households that buy firewood usually buy a truckload. Others collect firewood from their land, which can also cost around MXN 500 in gasoline. The LPG cylinder costs MXN 300. When reflecting on the fact that some participants already spend the same amount of money buying firewood that they would on LPG, one said: “I already looked at the LPG: In the rainy season I bought the LPG, a 20-L one (300 pesos). There I made my tortillas, there I cooked my maize and my bean, only 20 days it lasted.” Some said that 100 pesos of firewood last for 15–20 days. Those that buy firewood on a daily basis are spending more on firewood than what they would need for LPG, but they do not have the means for saving enough money to buy one cylinder of LPG or one truckload of firewood.

In the words of one participant: “Well, when they gave us the LPG I used it, but we ran out of LPG and we do not have enough money to be buying.” “[And when I had it] yes, I liked it, but that's why I say, if we run out of LPG, then firewood. The LPG is expensive, but I liked it.”

#### 3.4.5. What would you like for your daughters to use?

In the group of firewood users, we asked them what they would like their daughters to cook with. Many of them expressed that they would prefer them to use LPG, but one woman said otherwise:

“Let's see how luck plays, if she is going to get a city man, if she is going to get a rural man, we need to wait and see how her life is going to turn out. I do not know, I am going to teach her as poor people, I am going to teach her to make tortillas, to make a fire, to cook the maize, to make beans.”

## 4. Discussion

This case study provided a unique opportunity to assess the adoption of LPG by rural communities in Chiapas six years after a relocation program, where every household started with the same set of stoves and a full LPG cylinder. As we learnt, many households in both communities shifted from exclusively using firewood in their communities of origin, to using a mix of firewood and LPG six years after receiving the new houses (72 homes, 35 in JAL and 37 in IXH). We argue that allowing these households to use LPG for free for about a month, combined with the shortage of firewood in the new towns, gave them the opportunity to experience the advantages of cooking with LPG and provided the necessary motivation to continue using LPG. The LPG stoves provided by the Government of Chiapas were reportedly very low quality and only worked for around three months. However, more than 70% of households still use LPG to cook an average of 48–62% of their food despite the difficulties of having to pay for it. This means that they had sufficient incentives to buy an LPG stove (or bring the one they already had in their community of origin) and continue using LPG.

The experience in IXH may have been different, as the households in this community were provided “improved” cookstoves with chimney (ICS) in 2014, but none of those stoves remain in working conditions and no one tried to replace them. Unfortunately, our data does not allow us to draw strong conclusions on this matter, but it is reasonable

to speculate that the women and their families may not have experienced significant improvements in their cooking practices when using the ICS models, and did not feel the need to opt for similar models when those were displaced. This highlights the failure of these ICS programs in Mexico to achieve adoption and sustained use of this technology. In the context of a good LPG distribution system and market availability of LPG stoves, it is unfortunately that the Mexican government has privileged ICS distribution over supporting strategies to help rural families use cleaner fuels like LPG.

From the results of this study, it is clear that the main reason for not using LPG exclusively for cooking is its affordability for the energy-intensive task of making tortillas. In addition, the LPG stove models available in the market are not suitable for tortilla-making.

The survey results show that women spend between 35 and 70 h per month making tortillas depending on family size, whether they make them with Maseca (industrialized flour to prepare tortillas) or with nixtamal (that needs to be prepared and ground), and whether they collect the firewood or buy it. This means that women in rural communities in Mexico, and possibly in some Central American countries with similar cooking practices, use between 23 and 47% of their productive time to make up to 7 kilos of tortillas daily – something that most Mexican households buy in a tortillería.

It is important to note that preparing nixtamal requires big pots that usually need an open fire, as almost no ICS is good for cooking big quantities of food and doing so with LPG in non-industrial settings would be very expensive. This means that the only way for women to avoid using open fires is to stop making nixtamal. Likewise, the only way for them to stop using firewood is to stop making tortillas altogether, as they are so energy-intensive that using LPG is almost out of the question in a rural economy. This highlights the inequities that perpetuate bad health and poverty in these rural communities and questions the emphasis of most ICS programs on the ability of these stoves to make tortillas. Is it fair to provide a technology that maintains women's status quo? Would it not be preferable to free women from the task of making tortillas and allow them to do something more productive with 23–47% of their time? Many will argue that tortilla-making is a tradition and that it will be a shame to lose a cultural heritage, but should it not be those women that get to decide? Especially since it is a health risk factor and keeps them in the kitchen.

During focus groups, women expressed seemingly contradictory ideas, at times noting that the faster cooking fuel is LPG, and at other times saying firewood is faster. The reality is that either LPG or firewood can be the faster solution in different situations. LPG is an optimal choice for quickly cooking most food items because all that is required is the small flame of the gas stove. However, for large quantities of food, the open fire is more convenient and faster. Users have a clear vision for the ideal LPG stove: the stove should use less LPG and be larger with a bigger flame to cook hard foods in less time, multiple burners to cook several items at once,<sup>7</sup> a large comal to make tortillas, and preferably an oven. The focus groups also highlighted the need for high-quality stoves with a thick metal sheet to withstand the heat of the flame, dismountable burners, a safety valve, and spare parts available in the market. However, even if such ideal LPG stoves existed (tailor made to the very difficult task of making tortillas with a higher efficiency), tortilla-making with LPG would likely be unaffordable.

The scale of this study is relatively small and may not be representative of other traditional rural communities, as the studied population was subject of many changes and interventions. First, they were displaced from their place of origin and had no choice but to adapt to being grouped together in a completely new area with similar houses. Secondly, they were given the LPG cookstoves with a full cylinder, again without being given options. Although the community of IXH later received an ICS as well, households still had little or no

<sup>7</sup> The stoves given by the government had two burners.



participation in the decision-making process. As reported in the results, there are significant differences regarding adoption of LPG between JAL and IXH, the main one being the socioeconomic differences; but there are other factors that should be better assessed, such as the higher percentage of male involvement in the decision making regarding fuel use in IXH and the higher percentage (10% in IXH) of family preference for cooking with firewood for cultural reasons (“it is our custom”) as well. This highlights the importance of understanding people’s perceptions and their reasons behind decision making when proposing public policy.

The results presented here could inform tailored policies to accelerate the transition to clean cooking in Mexico and in other countries with similar cultural and socioeconomic background.

## 5. Conclusions and policy implications

*“One gets used to using wood and one gets used to using gas, whatever fits our needs”.*<sup>8</sup>

The use of firewood for cooking is deeply rooted within rural communities in southern Mexico. However, this study shows that the transition to other fuels such as LPG is possible. The study assessed the results of an intervention that provided an LPG stove and a full LPG cylinder to a set of households in 2011. By having access to the stove and the cylinder, households were able to realize the benefits of cooking with LPG. This led a significant number of households that previously used only firewood to start using LPG for cooking on a regular basis (38% of households made this shift). In households where LPG is used, it is used to prepare 58% of the meals on average.

This study shows that women have very clear notions regarding why and for what they use each fuel. This decision is clearly contingent on the family economy. Women expressed knowledge of the health Problems associated with smoke inhalation. Some specifically expressed having received medical instructions to avoid cooking with firewood for health reasons.

Stacking may reduce the health benefits obtained from clean cooking fuels, but it shows a clear transition. Understanding the drivers for change helps accelerate the transition, and this work sheds some light on these drivers and suggests some possible avenues.

The results presented here predict a positive outcome for the transition to the use of clean cooking fuels like LPG and could lay the foundation for future programs in rural communities. To promote such a transition, economic barriers to these cleaner fuels need to be addressed, potentially in the form of a targeted LPG subsidy such as the ones in El Salvador and Peru (Pollard et al., 2018; Troncoso and Soares, 2017) or an electricity subsidy as in Ecuador (Gould et al., 2018).

Given the significant amount of energy spent in preparing tortillas, an alternative transition strategy would be to subsidize the production of good-quality tortillas<sup>9</sup> made in tortillerías, either by placing a tortillería handled by the municipal authorities or by supporting the community to organize and form a cooperative to produce tortillas (with or without government support). This would also free between 9 and 19 h per week that women spend making tortillas. Tortilla subsidies have previously been implemented in Mexico: Between 1984 and 2003, different schemes were implemented with a poverty alleviation objective (Appendini, 2001; CESOP, 2004). These subsidy schemes targeted the urban poor (in cities with more than 15,000 inhabitants), and therefore it is unlikely that they had an impact on firewood users. However, a tortilla subsidy targeting solid fuel users could build on these experiences.

Valuing cultural and traditional knowledge is important. However,

it is also important to consider that traditions evolve, and there are health, time and environmental reasons for calling for a better solution that needs to be tested (such as supporting the production of tortillas). Traditional solutions like providing only an LPG stove or a biomass stove with chimney (ICS) have not achieved a complete change as people continue to cook some meals (mainly tortillas) in an open fire (Troncoso et al., 2007; Ruiz-Mercado et al., 2011). Some countries have opted for subsidizing LPG, a policy that has been shown to effectively reduce the use of solid fuels (when the subsidy is greater than 65%), but it is regressive and highly expensive when implemented as a universal subsidy (Troncoso and Soares, 2017). A pilot tortilla subsidy project as a strategy for the transition from solid fuels to clean fuels for cooking could inform other countries with similar cooking practices like Guatemala, Honduras, El Salvador, and Nicaragua.

Other technologies, such as the pressure cooker, could significantly reduce the cooking time of staple Mexican dishes, including beans. In addition, considering that the traditional stove stays on more than 20 h per week longer than the time it is in use, a technological innovation to allow a firewood stove to be turned on and off easily could help save up to 40% of firewood for those that cannot make the transition to clean fuels.

This study highlights the role of poverty in the use of firewood in Mexico and shows that cultural and social motives are superimposed onto economic reasons. Cooking with firewood is not only harmful to human health, the environment, and the climate, but it also represents around 50 additional hours per month for women spent in cooking-related activities. As such, minimizing economic barriers to improve access to cleaner fuels is both an opportunity to reduce inequalities and a means to support the achievement of SDG 7.

## Disclaimer

This study was approved by the Bioethics Commission of the state of Chiapas with the official letter No. 5003/00633 dated February 10, 2017. Karín Troncoso, Patricia Segurado and Agnes Soares da Silva are consultants and staff at the Pan American Health Organization. The authors are solely responsible for the opinions expressed in this publication, and do not necessarily represent the decisions or policies of the Pan American Health Organization.

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<sup>8</sup> The words of a woman in one of the focus groups.

<sup>9</sup> By good quality tortillas we mean tortillas made from nixtamal instead of Maseca, as preferred in rural areas. The flavor is different, and this would be a very important adoption factor.

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