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An evaluation of the Fondo de Inclusión Social Energético program to promote access to liquefied petroleum gas in Peru

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ABSTRACT

Introduction: Over 80% of rural households in Peru use solid fuels as their primary source of domestic energy, which contributes to several health problems. In 2016, 6.7 million Peruvians were living in rural areas. The Fondo de Inclusión Social Energético (FISE) LPG Promotion Program, which began in 2012 and is housed under the Ministry of Energy and Mining, is a government-sponsored initiative aimed at reducing use of solid fuels by increasing access to clean fuel for cooking to poor Peruvian households.

Methods: We conducted a mixed methods study incorporating data from publicly available records and reports, a community survey of 375 households in Puno (the province with the largest number of FISE beneficiary households), and in-depth interviews with community members and key stakeholders. We used the Reach, Effectiveness – Adoption, Implementation, Maintenance (RE-AIM) framework to guide our data collection and analysis efforts. In a sample of 95 households, we also measured 48-hour area concentrations and personal exposures to fine particulate matter ($PM_{2.5}$).

Results: The FISE LPG promotion program has achieved high geographical reach; the program is currently serving households in 100% of districts in Peru. Households with access to electricity may be participating at a higher level than households without electricity because the program is implemented primarily by electricity distributors. In a sample of 95 households, FISE beneficiaries experienced a reduction in kitchen concentrations of $PM_{2.5}$; however, there were no differences in personal exposures, and both kitchen and personal exposures were above the WHO intermediate target for indoor air quality. Among the 375 households surveyed, stove stacking with biomass fuels was reported in >95% of both beneficiary and non-beneficiary households, with fewer than 5% reporting exclusive use. In-depth interviews suggest that the complexity of the enrollment process and access to LPG distribution points may be key barriers to participating in FISE.

Conclusion: The FISE LPG Program has achieved high reach and its targeted subsidy and surcharge-based financing structure represent a potentially feasible and sustainable model for other government programs. However, the prevalence of stove stacking among FISE beneficiaries remains high. There is a need for improved communication channels between program implementers and beneficiaries. FISE should also consider expanding the mobile LPG network and community delivery service to reduce physical barriers and indirect costs of LPG acquisition. Finally, increasing the value of LPG vouchers to completely cover one or two tanks a month, or alternatively, introducing behavior change strategies to reduce monthly LPG usage, may facilitate the transition to exclusive LPG use.

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Background

Peru is an upper middle-income country with a population of approximately 31.5 million (2016) (World Bank, 2016a). In 2016, 6.7 million (21.1%) of Peruvians were living in rural areas (World

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Bank, 2016b). Peru has experienced rapid economic growth (6% annual increase in GDP) in recent decades (World Bank, 2016c). This coincided with a dramatic reduction in the population living below the national poverty line (176 soles or 54 USD per month), which fell from 49.2% to 20.7% between 2006 and 2016 (World Bank, 2016d). However, inequalities remain between urban and rural areas. In 2014, 46% of the population in rural Peru lived below the national poverty line, compared to just 15.3% of the urban population (World Bank, 2016e and 2016f). Similar differences exist when examining access to electricity and clean fuels for cooking; while 98.9% of the urban population had access to electricity in 2014, only 74.5% of the rural population had access (World Bank, 2016g and 2016h). Similarly, 81.8% of rural households in Peru primarily use solid fuels for cooking (typically wood, dung, and agricultural crop waste), compared to 9.8% of urban households, who typically cook with liquefied petroleum gas (LPG) or, to a lesser extent, natural gas (DHS, 2012). Solid fuel use leads to high exposure to household air pollution (HAP), which in turn increases the risk of morbidity and mortality due to various HAP-related health problems (GBD, 2017). In 2016, an estimated 5421 deaths nationwide were attributable to HAP (GBD, 2017). Thus, given the much higher reliance on solid fuels, rural populations may face a much greater burden of health problems caused by HAP exposure than urban populations.

Puno, Peru is a region in the Andes mountains located in the southeast of the country with 65% of the population living in rural areas (DHS, 2014). In addition, 70.5% of the population falls in the lowest two wealth quintiles, making the distribution of rural residents and individuals living in poverty comparable to those of mountainous regions of Peru (DHS, 2014). In 2016, 32.8% of the population of Puno used LPG for cooking (INEI, 2007). A 2015 study showed that in Puno, daily biomass use was associated with a 2.2-fold increase in odds of COPD among adult women (Jaganath et al., 2015). Furthermore, the population attributable risk for daily biomass use for COPD in adult women in Puno was 55% (Jaganath et al., 2015). Daily biomass use was also associated with increased risk of hypertension (RR 3.5, 95% CI 1.7 to 7.0) (Burroughs Peña et al., 2015).

Prior research shows that urban households in Puno that use LPG as their primary cooking fuel experience $PM_{2.5}$ concentrations below World Health Organization (WHO) safe levels (22 μg/m^3), whereas rural homes that use biomass (median of 24-hour averages 130 μg/m^3, $p < 0.001$) do not (Pollard et al., 2014; WHO, 2014). Modeling based on laboratory emission data suggests that exclusive LPG use would allow 94% of homes to meet the WHO air quality guidelines for $PM_{2.5}$ (WHO, 2014). However, using a traditional stove for an average of just 10 min per day was found to raise $PM_{2.5}$ concentrations above WHO annual guidelines; thus, even a small amount of stove stacking can decrease the potential benefits of clean fuels (Johnson & Chiang, 2015).

Many clean fuel options exist (e.g. electricity, natural gas, LPG, ethanol, and biogas); however, LPG is likely the most feasible clean fuel for widespread implementation in Peru in the short- to medium term. LPG is already commonly used in Peru, with a supply that is almost entirely produced nationally, and 85% of it is produced from gas processing. Peru is the fifth largest consumer of LPG as a cooking fuel in Latin America, behind Mexico, Brazil, Argentina, and Venezuela (WLPGA & Argus, 2017). Peru operates with an LPG cylinder recirculation model, in which consumers exchange empty cylinders for different full ones from LPG retail locations (instead of refilling cylinders that they own). The standard size of LPG tanks in Peru is 10 kg, costing on average 34 soles (approximately 10 USD).

The Ministry of Energy and Mining (MINEM) is the main branch of the Peruvian government focused on achieving universal access to electricity and clean fuel for domestic use. MINEM created a Plan for Universal Access to Energy 2013–2022 (FISE, n.d.a) based on the acknowledgement that access to energy is an essential pillar for addressing poverty and improving education, health, security, and productivity. The four major components of this plan include: expansion of natural gas (domestic and vehicular); expansion of renewable electricity; compensation for residential electrical costs; and, promotion of LPG for domestic use. This plan also leverages resources allocated to Peru's National Plan for Rural Electrification 2013–2022 (FISE, n.d.a).

The Fondo de Inclusión Social Energético

The Fondo de Inclusión Social Energético (FISE), or the Fund for Social Inclusion for Energy in English, is one of the mechanisms by which MINEM is currently carrying out its plan for universal energy access. FISE is an ongoing subsidy-based program implemented by the Peruvian government in collaboration with private energy distributors at the national level and was established in 2012 as a public policy for social inclusion. The primary objective of the program is to provide the most vulnerable populations with access to cleaner energy, targeting households living in poverty or extreme poverty (FISE, n.d.b). Although improving health was not the primary stated objective of the program, according to key stakeholders, health benefits are recognized as important program outcomes.

FISE is a multi-component initiative that includes several programs to increase access to clean energy, including the LPG Fuel Access Promotion Program. The FISE LPG program centers around the monthly provision of a voucher worth 16 soles (approximately 5 USD) to eligible families. An act of Congress is required to change the value of the voucher. The voucher is used to exchange an empty 10 kg LPG cylinder, costing 32 soles (approximately 10 USD) for a full one.

The FISE LPG program is targeted toward households living in poverty or extreme poverty. Beneficiary households must meet the following eligibility criteria (FISE, n.d.c):

- Household income less than S/. 18,000 (USD 5500) per year
- Household does not have electricity, or is connected to electricity with an average monthly consumption <30 kWh
- Precarious housing (i.e. no running water, unreinforced adobe or thatch material, etc.)
- Household is classified as extreme or non-extreme poverty by the Sistema de Focalización de Hogares (SISFOH) (http://www.sisfoh.gob.pe)
- Household has an LPG stove

MINEM previously supported a program separate from FISE ("Cocina Peru") that provided an LPG stove kit to poor families; however, this program is currently inactive. Currently, LPG stoves are not subsidized and must be purchased by beneficiaries; LPG stoves cost approximately S/0.50 (USD 15) soles to purchase independently. To receive vouchers, households with electricity must register with their electricity provider; those without electricity must register with their local MINEM office. Once eligibility is confirmed, vouchers are provided via electronic code on the monthly electricity bill for households with electricity, or via paper vouchers for households without electricity. FISE beneficiary households must use at least one LPG voucher within a four-month period or their beneficiary status is temporarily suspended. Beneficiary status is inactivated after one year of non-use, in which case households must re-enroll.

The FISE LPG program is a collaborative effort involving public and private actors. The Supervisory Organism of Investment in Energy and Mining (OSINERGMIN), housed within MINEM, is currently the primary body responsible for administration of the program. Electricity distribution companies (Empresas de Distribución Eléctrica, or EDEs) act in a supervisory, administrative, and operational capacity at the regional level. EDEs are responsible for maintaining the census of beneficiaries, distributing LPG vouchers to FISE households with and without electricity, and enrolling and overseeing local private LPG retailers. EDEs also carry out much of the marketing and promotion efforts of the program, which include radio spots, online promotional videos, banners, flyers and pamphlets, presentations at community meetings, and school-based outreach.

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Local LPG retailers ("LPG agents") directly supply LPG to beneficiaries and receive reimbursements from OSINERGMIN via text message-based electronic transfer. LPG agents are often small, local vendors or shop owners, recruited locally by EDEs. LPG retailers can purchase LPG cylinders from any LPG distribution company, such as LlamaGas, SolGas, or LimaGas in Puno. Retailers then sell the cylinders to consumers either with or without FISE vouchers; there is no specific "FISE" brand of LPG cylinder. Participating in FISE provides LPG agents with an additional source of income, and the FISE program benefits from having a wide network of agents for beneficiaries to access. OSINERGMIN has established a specific process and set of prerequisites for becoming an LPG agent, including storage safety, ventilation, etc. LPG agents sign an official agreement with OSINERGMIN to operate their stores in accordance with the rules of the program. LPG agents may be "fixed" or "mobile"; fixed agents sell LPG cylinders out of a physically located store, while mobile agents increase access for people in remote areas through a community-based delivery service. LPG agents operate within specific districts or regions, with the goal that agents be dispersed throughout the area.

FISE is funded by surcharges on other customers in the energy sector. These include a 2.5% surcharge on monthly electricity bills of unregulated electricity consumers (i.e. users ["Usuarios Libres"] not subject to price regulation for the energy or power they consume, such as large industrial facilities), a surcharge of approximately one USD per barrel on sales of liquid hydrocarbon products and natural gas liquids, and a tax on natural gas consumers for transmission services (0.055 USD per million BTU) (APEC, 2014).

The objective of this paper is to present a case study of the FISE LPG Access Promotion Program. We aim to understand the successes and challenges of the program with regard to reach (coverage), effectiveness (e.g. environmental and potential health impacts), adoption (effect on LPG use and exclusive use), implementation (e.g. program operations), and maintenance (i.e. sustainability) (Glasgow, Vogt, & Boles, 1999). The ultimate goal is to identify lessons learned that could improve the health impact of the FISE program among targeted households. The findings can also inform efforts to promote clean fuels for vulnerable populations in other countries.

Methods, sources, and approach

Study design

This case study incorporates national and regional data from secondary sources, as well as primary data collected in Puno, Peru. We employed a mixed-methods design in which quantitative and qualitative data were collected concurrently.

Given the survey-based nature of the study and the fact that no sensitive data or identifying information was collected, this study was acknowledged as exempt from review by the Johns Hopkins University School of Medicine Institutional Review Board (IRB #00144244) and approved by the Asociación Benéfica PRISMA Institutional Review Board.

Study setting

Primary data collection was conducted in rural communities of Puno, Peru. Puno province is located in southeastern Peru. Puno city, located on the shore of Lake Titicaca at 3825 m above sea level, is the capital of the province with approximately 230,000 inhabitants (INEI, 2007). There are 15 rural districts in Puno province, each containing up to 20 communities. 65% of the population of Puno lives in rural areas (DHS, 2014).

Puno was purposively selected because it currently includes the largest number of FISE beneficiaries and has the largest network of LPG agents in Peru (specific numbers in the results section). Additionally, the research team has an established research infrastructure and nine years of experience working in this region, thus facilitating data collection efforts. According to the 2014 Demographic Health Survey in Peru, only 13.3% of people living in urban Puno reported using wood, dung, or other biomass for cooking (DHS, 2014). Nearly 84% of urban residents used LPG as their primary cooking fuel in 2014, and this has likely increased in tandem with national increases. In contrast, 65% of the Puno population lives in rural areas, and 87.9% of these rural residents use primarily biomass for cooking. Additionally, only 23.2% of urban residents fall in the lowest two wealth quintiles that would qualify for FISE benefits, compared to 95.8% of rural residents in the lowest two wealth quintiles. Thus, our study focused on rural Puno where biomass use and FISE eligibility were likely to be highest.

Data sources and procedures

Community-based survey

We surveyed 375 households in 53 rural communities of Puno. Households were selected using simple random sampling from a community-wide census conducted by PRISMA between 2015 and 2017 in 12 districts. The survey included questions about household and participant sociodemographics, stove and fuel use, and experiences with the program. Questions related to barriers and facilitators to adoption of clean fuels were developed based on prior research (Hollada et al., 2017; Puzzolo, Pope, Stanistreet, Rehfuess, & Bruce, 2016), as well as consultation with key informants. We obtained oral informed consent and surveyed one member of each household 18 years of age or older capable of providing informed consent and answering the survey questions.

In-depth interviews with community members and key stakeholders

A field staff member conducted 14 in-depth, semi-structured interviews in Spanish. Interview guides included questions related to the components of the Reach, Effectiveness, Adoption, Implementation, Maintenance (RE-AIM) framework (Glasgow et al., 1999). Six interviews were conducted with key stakeholders involved in the implementation of the program. This included representatives from the central administrative offices of the program, regional electricity distributors, LPG agents, and local authorities (community governors) in Puno. Eight interviews were conducted with community members, including three current FISE beneficiaries, three previous FISE beneficiaries, and two who have never participated. Quantitative survey participants who were forthcoming with information on their experiences and indicated having knowledge relevant to the reach, effectiveness, or adoption of FISE were purposively selected to participate in a qualitative interview immediately following the survey.

Environmental exposure assessments

As part of a separate ongoing study, in 95 households, we assessed HAP exposure by measuring kitchen concentrations and personal exposures to $PM_{2.5}$ over 48-hour periods. Between February and September 2017, we sampled 48 households who had participated in FISE and 47 participants who had never participated. The sampled households were in low-density farming communities with houses located a median of 101 m from the closest neighbor. <4% of houses within these communities were located within 100 m of a highway, and ambient air pollution is minimal (Fandiño-Del-Rio et al., 2017).

The ECM real time aerosol monitor (RTI Inc., Research Triangle Park, NC, USA) was used to measure both direct-reading concentration and gravimetric samples of $PM_{2.5}$. Kitchen concentrations were measured by placing instruments approximately 1 m from the combustion zone of the traditional stove, 1.5 m above the floor, and at least 1 m from doors and windows when possible. Instruments for personal exposure were worn in an apron provided to participants, situated in a pocket approximately at the participant's breathing zone.

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Secondary data sources

We used data from publicly available sources, including the Peruvian National Institute for Statistics and Informatics (INEI) and the World Bank Open Data, as well as published reports from FISE and the Asia Pacific Economic Corporation (APEC) to inform this case study. We also included administrative data provided by FISE for additional information.

Analytical methods

We employed the RE-AIM analytical framework (Glasgow et al., 1999) to guide data collection efforts and evaluation of the FISE program. We used *t*-tests and chi-squared tests to assess differences between FISE participants and non-participants with respect to continuous and categorical variables, respectively. National equity index quintile was calculated by applying standard weights from the Demographic Health Survey based on ownership of key assets (computer, bookshelf, curtains, sofa, improved sanitation, type of roof, and wall material). We conducted simple logistic regression to determine the barriers associated with voucher exchange behaviors.

All interviews were digitally recorded, transcribed verbatim, and analyzed in Spanish. Transcripts were coded using a coding scheme developed a priori based on the RE-AIM framework. Additional themes were also identified deductively as they emerged during the analysis. Two researchers separately reviewed the same two transcripts to confirm application of codes, and the remaining transcripts were divided among the researchers for coding. Once coded, quotes were synthesized and summarized into key points for each RE-AIM component.

Results

Reach

The number of FISE LPG program beneficiaries has increased steadily over time. FISE's reach now extends to 100% of regions and 98.1% of districts in Peru. In October 2017, the number of LPG beneficiary households registered with the FISE program reached 1,566,587 households nationwide. Of those 1,566,587 households, 928,816 (59.3%) received vouchers, 412,789 (26.3%) were inactive, and 224,982 (14.3%) were suspended. Administrative records from FISE indicate that 825,145 (88.8%) of the households who received vouchers exchanged them for LPG cylinders. Puno has the most beneficiary households, representing 15.0% of total beneficiaries, followed by Cusco and Cajamarca (Fig. 1a). The number of LPG agents has also increased steadily over time, reaching 4587 LPG agents as of October 2017. This number corresponds to a ratio of one agent per 342 households on average. Puno has the highest number of LPG agents (1184), followed by Cusco (371) and Cajamarca (347) (Fig. 1b).

Results from our community survey in Puno indicate that 90.1% (338/375) of household members surveyed had heard of FISE. 74.9% of the 338 participants who had heard of FISE learned of the program through their community governors/local authorities. Family members (9.76%) and radio spots (6.51%) were also cited frequently as sources. 60.3% (226/375) of respondents reported having ever participated in the program, and 90.2% (203/225) of ever-beneficiaries reported having exchanged an LPG voucher within the past year.

In Table 1, we summarize demographic and household characteristics of FISE beneficiaries and non-beneficiaries in Puno. National wealth index, household size, and connection to a public water source did not differ by FISE status. Non-FISE beneficiary households were more likely to have unfinished adobe walls than FISE beneficiaries. 88.5% (331/374) of households surveyed had access to electricity; however, FISE beneficiary households were more likely to have access to electricity than non-beneficiary households ($p = 0.05$). Having access to electricity was significantly associated with a 4.4-fold higher adjusted odds of having participated in FISE, after adjusting for household size, head of household occupation, and whether the family cooks for animals. Although we were unable to directly assess eligibility, data from Table 1, including precarious housing indicators, wealth status, and energy use, indicate that most households surveyed (>95%) would likely qualify for the program.

FISE beneficiary households were significantly more likely to currently use an LPG stove than non-beneficiary households (Table 2).

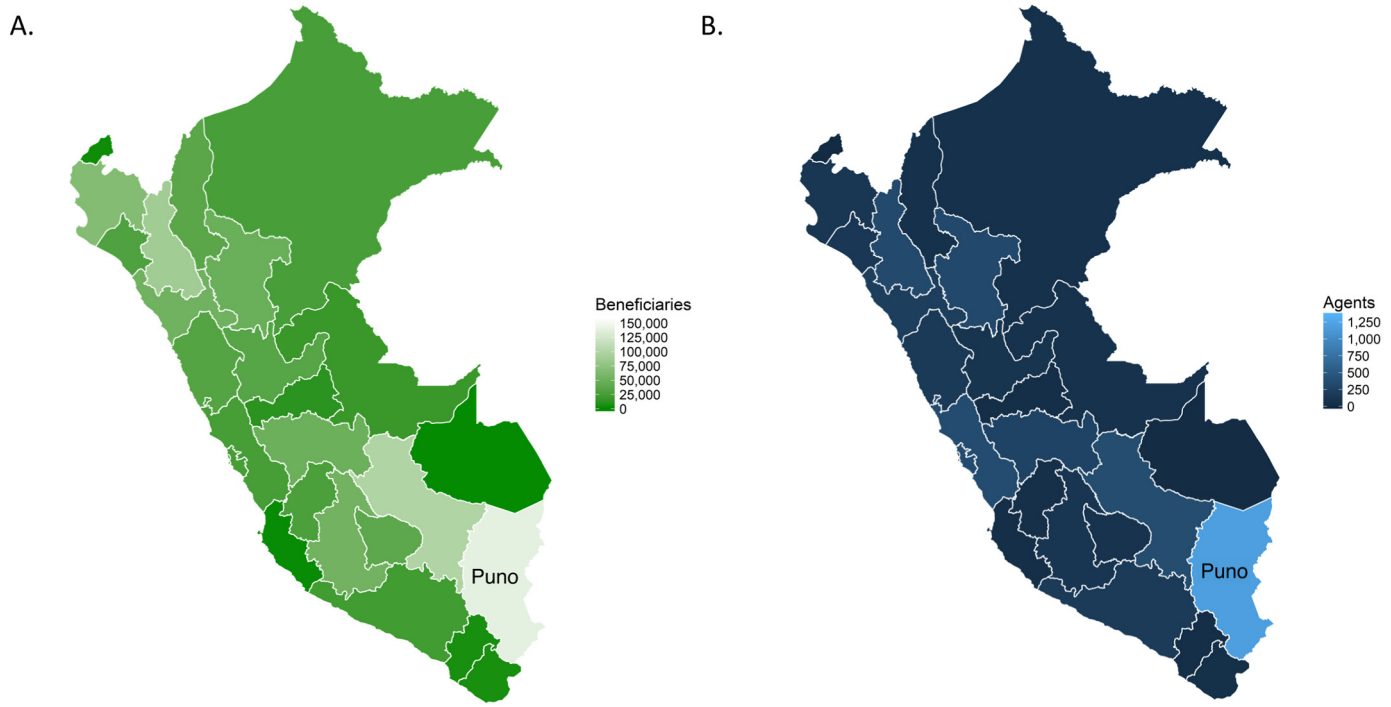

Fig. 1. (a) Number of households participating in the FISE LPG promotion program by region and (b) Number of active, registered LPG agents in October 2017 by region of Peru.

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Table 1
Demographic and socioeconomic characteristics of FISE beneficiaries and non-beneficiaries in Puno, Peru.

	Total	FISE beneficiaries	Non-FISE beneficiaries	p-Value
	n = 375	n = 226	n = 149	
Sociodemographic characteristics				
Belongs to lowest two national equity quintiles	353/373 (94.6)	214/226 (94.7)	139/147 (94.6)	0.55
Household size 3+, n(%)	215/371 (58.0)	130/224 (58.0)	85/147 (57.8)	0.97
Has cell phone w/text messaging, n(%)	197/338 (58.3)	112/204 (54.9)	85/134 (63.4)	0.12
Knows SES (SISFOH) category, n(%)	36/375 (9.6)	27/226 (12.0)	9/149 (6.0)	0.06
Electricity access and use				
Electricity, n(%)	331/374 (88.5)	205/225 (91.1)	126/149 (84.6)	0.05
Electricity consumption <30 kWh	360/373 (96.5)	218/224 (97.3)	142/149 (95.3)	0.42
Housing conditions				
Home not connected to public water source	373/374 (99.7)	0/226 (0.0)	1/148 (0.7)	0.22
Has unfinished adobe walls, n(%)	297/375 (79.2)	173/226 (76.6)	124/149 (83.2)	0.03
Has a corrugated iron roof, n(%)	353/375 (94.1)	213/226 (94.3)	140/149 (94.0)	0.58
Primary toilet is treated pit latrine, n(%)	269/375 (71.7)	155/226 (68.6)	114/149 (76.5)	0.14
LPG stove				
Currently uses LPG stove, n(%)	255/375 (68.0)	218/226 (96.5)	37/149 (24.8)	<0.001
Received first LPG stove from government program (separate from FISE) (among people who have LPG stoves)	78/253 (30.8)	76/216 (35.2)	2/37 (5.4)	0.004

Effectiveness

In Fig. 2, we display the results of 48-hour kitchen concentrations and personal exposures to $PM_{2.5}$ in 48 FISE beneficiary households and 47 non-beneficiary households living in rural communities of Puno. Our results suggest that there is lower HAP exposure in households that are FISE beneficiaries compared to non-beneficiaries. Median 48-hour kitchen $PM_{2.5}$ concentrations were 30% lower in FISE beneficiary households (695 μg/m^3, IQR 820) vs. non-beneficiary households (999 μg/m^3, IQR 1345), a difference that reached statistical significance (Wilcoxon rank sum test p-value <0.01). Median 48-hour personal $PM_{2.5}$ concentrations were 24% lower in FISE beneficiaries (63 μg/m^3, IQR 86) vs. non-beneficiary participants (83 μg/m^3, IQR 93), although this difference did not reach statistical significance (Wilcoxon rank sum test p-value 0.49).

The leadership in OSINERGMIN is currently planning to carry out an impact evaluation at the national level, which will include evaluations of both environmental exposures and health impact.

Adoption

Program adoption and voucher use

Administrative data indicate that nationwide, between 2012 and October 2017, 74.4% (34,870,914/46,867,453) of vouchers distributed to beneficiary households were exchanged for LPG.

Survey results indicate that beneficiary households (average household size of 3.1 members) exchanged vouchers a mean of 9.3 months in the previous year (n = 225); 64.9% (146/225) of beneficiary households reported exchanging vouchers 12 months in the previous year, and 16.0% (36/225) exchanged vouchers six or fewer months in the previous year. In addition, 94.6% (192/203) reported using the vouchers at least once in the previous three months. In simple logistic regression modeling, we found that viewing the voucher exchange process as difficult was associated with a 50% decreased odds of exchanging a voucher for six or more months in the previous year (p = 0.01). However, data from in-depth interviews indicate that community members will sometimes combine vouchers from previous months to cover the

Table 2
LPG stove adoption and fuel use patterns among 375 representative households in Puno, Peru.

	Total	FISE beneficiaries	Non-FISE beneficiaries	p-Value
Any stove use				
Currently uses LPG stove, n(%)	255/375 (68.0)	218/226 (96.5)	37/149 (24.8)	<0.001
Currently uses traditional open fire stove	361/375 (96.3)	215/226 (95.1)	146/149 (98.0)	0.15
Currently uses improved biomass cookstove[a]	3/375 (0.8)	2/226 (0.9)	1/149 (0.7)	0.82
Uses LPG stove exclusively, n(%)	13/375 (3.5)	10/226 (4.4)	3/149 (2.0)	0.21
Adopted LPG after FISE		210/226 (92.9)		
Additional fuel use				
Wood	201/375 (53.6)	132/226 (58.4)	69/149 (46.3)	0.02
Dung	344/375 (91.7)	204/226 (90.3)	140/149 (94.0)	0.20
Crop waste	142/375 (37.9)	65/226 (28.8)	77/149 (51.7)	<0.001
Kerosene	6/375 (1.6)	1/226 (0.4)	5/149 (3.4)	0.03
Alcohol	21/375 (5.6)	11/226 (4.9)	10/149 (6.7)	0.45
Charcoal	1/375 (0.3)	0/226 (0.0)	1/149 (0.7)	0.40
Fuel use patterns				
No. of LPG cylinders used per month among LPG users, mean (SD)	1.1 (0.4) n = 256	1.1 (0.4) n = 219	1.1 (0.4) n = 37	0.91
% of weekly meals cooked on LPG stove on average among LPG users	60.6 (25.9) n = 256	61.2 (25.5) n = 219	57.6 (28.5) n = 37	0.43
Cooks for animals	277/373 (74.3)	171/225 (76.0)	106/148 (71.6)	0.91

[a] Biomass-burning cookstove manufactured for improved combustion efficiency.

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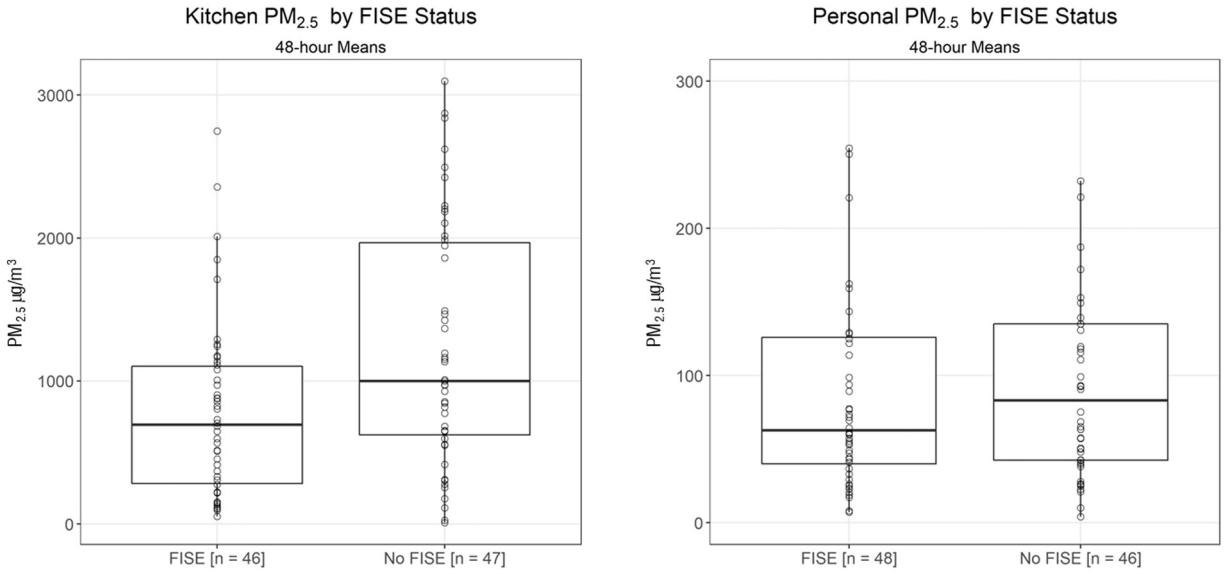

Fig. 2. Kitchen and personal 48-hour mean concentrations of $PM_{2.5}$ in FISE beneficiaries and non-beneficiaries.

full cost of an LPG cylinder. Thus, although they may only use vouchers for six months out of the year (obtaining one LPG cylinder every two months), all 12 of the vouchers provided over the course of the year may be used in those cases.

LPG stove adoption

There were no data available regarding stove or fuel use patterns among FISE beneficiaries nationally. Although national trends indicate a steady increase in any LPG use over time in rural areas and overall (Fig. 3), the prevalence of exclusive LPG use increased only modestly across all settings.

Of the 375 households interviewed in the community survey, 255 (68.0%) report that they currently use an LPG stove. Beneficiaries were significantly more likely ($p < 0.001$) to report current use of an LPG stove (96.5%, 218/226) compared to non-beneficiaries (24.8%, 37/149). The majority of FISE beneficiaries report using only biomass fuels prior to making the decision to enroll in FISE. However, fewer than 5% of respondents overall and within beneficiary groups reported exclusive use of LPG. FISE and non-FISE beneficiaries who currently cook with LPG report preparing approximately the same percentage of their meals per week with LPG (Table 2).

Among households that used LPG stoves, 94.9% (242/255) reported stacking with biomass-burning traditional stoves. The prevalence of stove stacking was not significantly different between FISE beneficiaries and non-beneficiaries currently using an LPG stove. There was no difference in exclusive use of LPG (4.8% vs. 5.9%, $p = 0.71$) between households that purchase their LPG stove ($n = 168$) as compared to families who acquired it by other means ($n = 85$).

Alternative stove and fuel use patterns

In Fig. 4, we display the trends in fuel use nationally (6A) and in rural areas (6B). The prevalence of wood only use decreased by 62% nationally and by 54% in rural areas between 2003 and 2016. The prevalence of mixed biomass use in rural areas decreased by 30% in this same

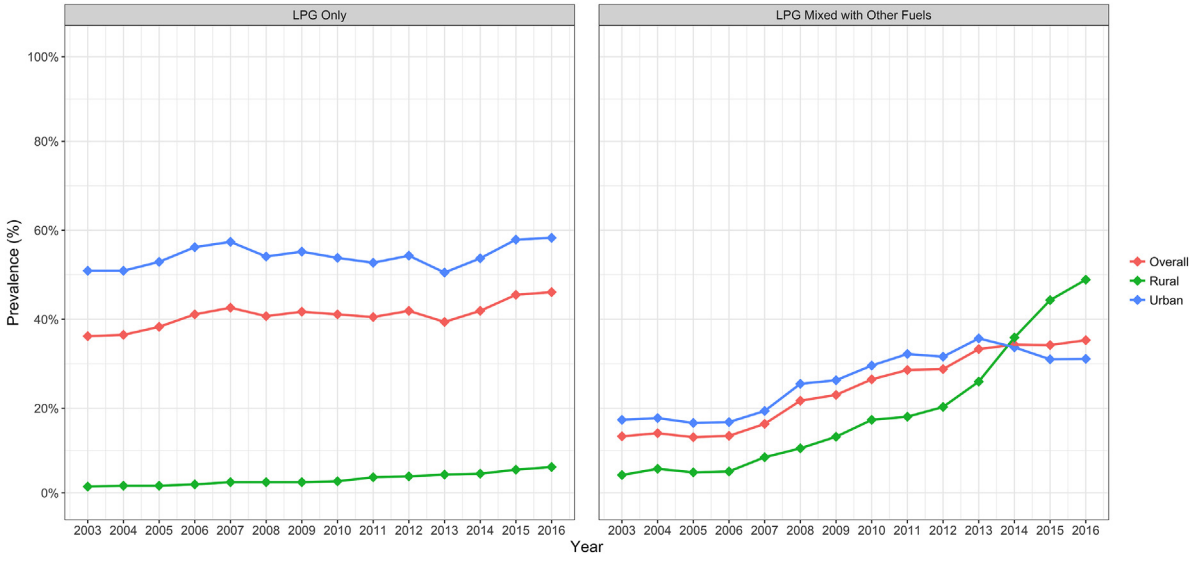

Fig. 3. Prevalence of mixed LPG use (with solid fuels) and exclusive LPG use in Peru from 2003 to 2016. Source: inei.gob.pe.

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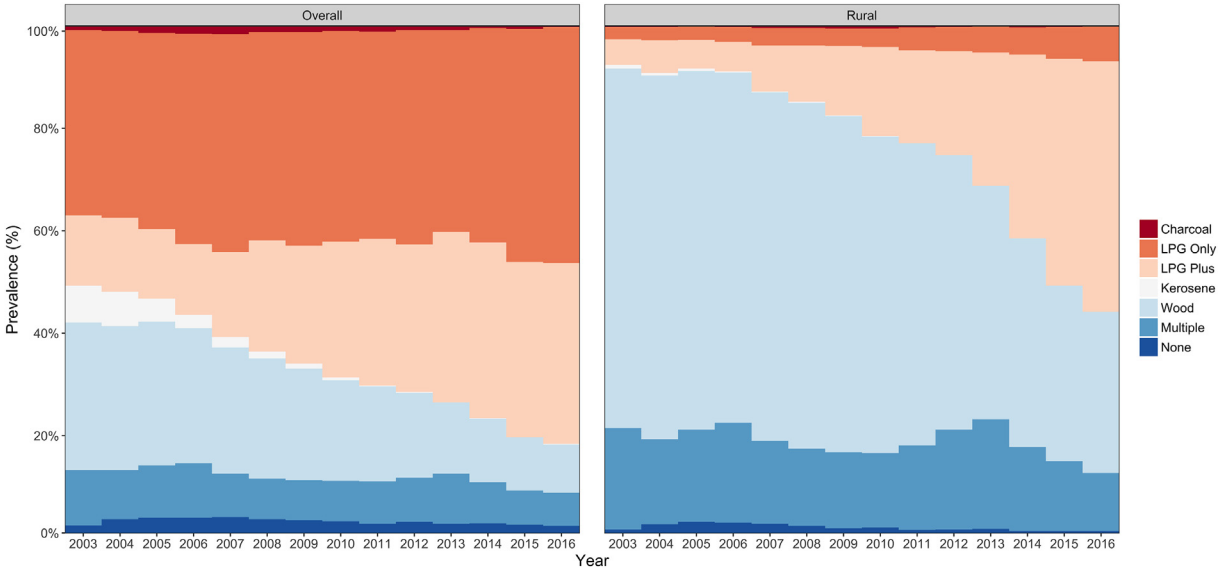

Fig. 4. Prevalence of fuel use overall and in rural households in Peru from 2003 to 2016. "LPG Only" represents exclusive LPG use, "LPG Plus" represents mixed LPG use (with solid fuels), "Multi" represents mixed biomass fuel use. Source: inei.gob.pe.

period. Charcoal and kerosene use were consistently below 3% nationally and 0.5% in rural areas. Use of electricity or induction for cooking is rare in urban and rural Peru.

In Table 2, we display the prevalence of self-reported current use of additional fuels based on results from the Puno community survey. Dung was the most commonly used alternative fuel, followed by wood and crop waste. Use of dung and wood did not differ significantly by FISE beneficiary status, while use of crop waste was significantly higher among non-beneficiary households. Though the overall prevalence of kerosene use was <5% in both groups, kerosene was used significantly more frequently among non-beneficiaries.

In Fig. 5, we display self-reported stove preference for different seasons among households that use LPG (n = 226). Table 3 outlines the months corresponding to each season. LPG was preferred during the rainy and windy seasons, with 68.8% (176/256) and 50.2% (128/255) preferring LPG in these seasons, respectively. Traditional biomass-burning stoves were preferred in the harvest (43.8%, 112/256) and cold (41.0%, 105/256) seasons, as well as during festivals (56.8%, 143/252), which occur throughout the year. Stove preference did not differ significantly between FISE beneficiaries and non-beneficiaries in any season.

Perceived benefits and barriers to adoption of LPG

Community members in Puno described several benefits to using LPG. During in-depth interviews, several community members noted that using LPG allows them to maintain cleaner hands, clothes, pots, and kitchens as compared to using a traditional open-fire stove

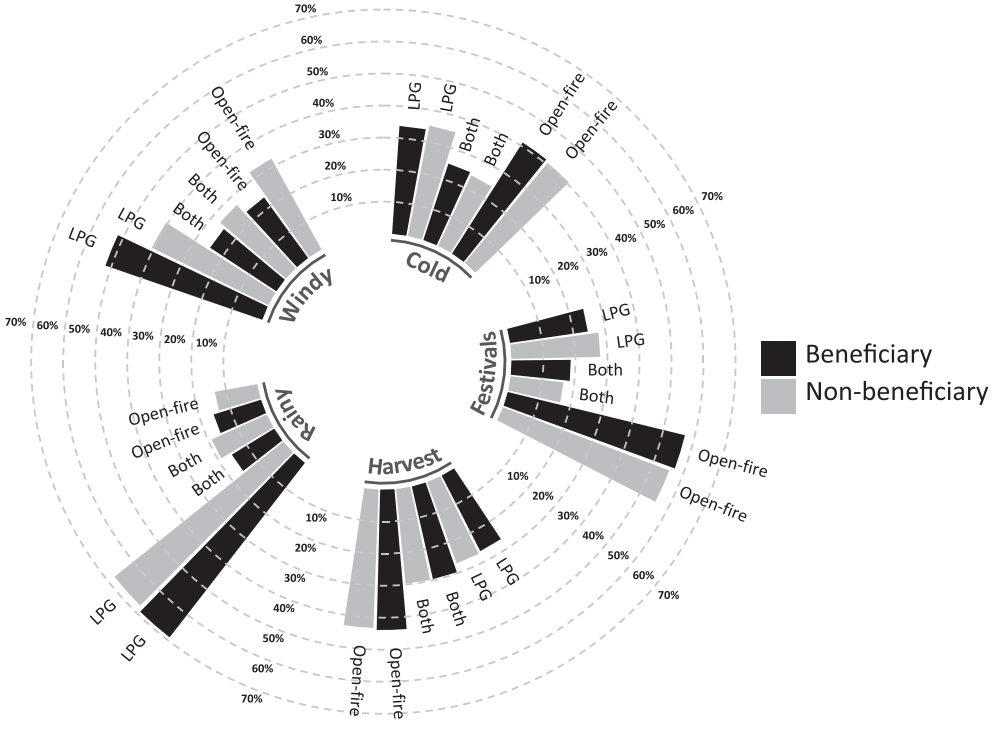

Fig. 5. Stove preferences by season among FISE beneficiaries and non-beneficiaries.

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Table 3
Calendar months for seasons.

Season	Start	End
Windy	August	August
Rainy	December	February
Cold	June	August
Harvest	April	May
Festival	Throughout the year	

(*fogón*). Participants also reported that cooking with LPG saves time, allowing them to cook faster and more often. Community members also viewed the reduction in smoke emissions as beneficial to their health and the health of their families. Many noted that they experience less coughing, headache, burning eyes, and lung irritation when cooking with LPG.

There are several barriers to LPG adoption and biomass "dis-adoption" in Puno. Some people expressed that food tastes better when cooked with a *fogón*, limiting their desire to participate in FISE and use LPG.

> "[*On the fogón*], *food is more delicious, it is more natural.*" – *Community member not participating in FISE*

Other participants reported that people are afraid of LPG and are unsure how to use it. One participant suggested that more training is needed for people to feel comfortable adopting LPG.

> *FISE should have a training for all the beneficiaries, on how to use the gas stove, how to do everything… Now they don't know… when the children leave, the elderly stay and they do not use the gas stove.* – *Community member participating in FISE*

Perceived barriers to adoption of the FISE program

The complexity of the enrollment process and confusion about eligibility emerged as important barriers to adoption. Among the 149 households in the community survey who had never participated in FISE, 41 (27.5%) reported not participating in FISE because they do not know how to sign up. Others are not fully informed about the eligibility criteria. For example, 90.4% (199/226) of beneficiary households and 94.0% (140/149) of non-beneficiaries did not know their SISFOH status, a key component of FISE eligibility criteria. In addition, because electricity companies participate in implementing the FISE program, many participants believe they must have electricity to participate; thus, those without electricity often do not attempt to enroll. Additionally, 14.8% (22/149) of households who were not participating in the program reported having submitted all requirements but never hearing word of whether they qualified; many of these households assumed they were ineligible but were unsure why.

> *I presented* [*my papers*] *but they still haven't responded.* – *Community member not participating in FISE*

> *I went to* [*local electricity distributor*] *and they don't help me, I walk two hours and pay the fare and they told me they don't enroll people anymore; I got tired of it and gave up.* – *Community member not participating in FISE*

Barriers related to voucher exchange and LPG supply chain

One common challenge described by community members were issues with the supply chain and logistics of exchanging LPG cylinders. In Puno, most rural communities are remote, and public transportation is inconsistently available. According to the community survey, the overall mean reported amount of time to retrieve an LPG cylinder was 66.8 min among FISE beneficiaries and 93.4 min for non-FISE beneficiaries. Retrieving the LPG cylinder can require carrying the cylinder in a wheelbarrow to the highway and waiting for a bus, which will sometimes charge passengers extra for carrying the cylinder onboard.

> [*One must go*] *all the way to the bus stop on the Panamerican highway …* [*carrying the LPG cylinder*] *25 minutes with a wheelbarrow … Wait for the bus … five, ten minutes if you're lucky.* – *Community Governor*

In the community survey, 16% (36/226) of households reported arriving at an LPG retail location and finding no LPG cylinders available (Table 4). There is also a common perception in the community that the LPG cylinders provided by FISE do not last as long as the cylinders purchased outside of the program, though both are the standard 10 kg size and produced by the same LPG distribution companies. We found that 62.3% (119/226) of FISE beneficiaries surveyed reported the fact that FISE cylinders run out quickly as a barrier to participating in the program. Additionally, 33.9% (76/226) of beneficiaries reported fluctuation in the cost of exchanging LPG cylinders as a barrier (Table 4).

Influence of direct and indirect fuel costs on LPG adoption

Vouchers provided by FISE reduce the reported monthly fuel costs for cooking for beneficiary households. FISE beneficiaries reported spending S/. 18.10 (USD 5.57) on fuel for domestic use per month. Among FISE beneficiaries, 27.1% (61/225) indicated that they purchase fuel without a voucher, and these households report spending a total of S/. 34.90 (USD 10.74) on fuel in non-voucher months.

Many participants expressed frustration that FISE only provides one voucher per month to each household, as one cylinder of LPG is not sufficient to cover their monthly cooking requirements. We found that 87.5% (196/226) of FISE beneficiaries reported being challenged by the fact that the voucher covers only S/. 16 (USD 4.92) per month. Given that beneficiary households currently report cooking 61.2% of meals on their LPG stove and using 1.1 cylinders per month (i.e. 11 kg of LPG for an average household of 3.1 members), we can estimate that households would need approximately 1.8 cylinders per month (i.e. 18 kg of LPG) to support exclusive use.

Program satisfaction

Despite the barriers reported by FISE beneficiaries (Table 4), 81.1% reported being satisfied or very satisfied with the program, and 100% report that they will continue to participate in the future.

Table 4
Self-reported barriers experienced by FISE beneficiaries in rural Puno, Peru.

Barrier	Survey results (n = 226)
Does not know their SISFOH[a] category	199 (90.4)
Report FISE cutting LPG voucher program service to their home as a barrier	48 (21.4)
Report FISE cutting LPG voucher program service to their community as a barrier	15 (6.70)
Find it difficult or very difficult to exchange LPG voucher	10 (4.42)
Report LPG voucher-cylinder exchange process is confusing	149 (66.2)
Report that the time required to exchange LPG voucher for LPG cylinder is a barrier	173 (76.9)
Report tanks provided by FISE don't last as long as tanks available outside of the FISE program	139 (62.3)
Have experienced no LPG at a FISE-approved LPG agent location	36 (16.0)
Report that it is a barrier that the LPG voucher only covers half an LPG cylinder	196 (87.5)
Report changing costs of cylinder as a barrier	76 (33.9)
Satisfied or very satisfied with the program	187 (82.7)
Report they plan to continue to participate in FISE LPG program in the future	226 (100)

[a] SISFOH is the "Sistema de Focalización de Hogares," a national household targeting system that places households into socioeconomic categories (sisfoh.gob.pe). Being in SISFOH categories 1–5 is one of the criteria for eligibility in the FISE program.

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Implementation and maintenance

Monitoring and evaluation efforts and program adaptation

FISE has systems in place for the EDEs and OSINERGMIN to continually monitor beneficiary eligibility and misuse of LPG vouchers on the part of both beneficiaries and LPG agents.

One of the key activities of the EDEs is to regularly maintain the list of eligible households within their regional catchment area. The purpose of this is to prevent the provision of vouchers to households who do not meet eligibility criteria for the program. SISFOH provides FISE with information regarding socioeconomic status and housing conditions, and the EDEs monitor eligibility based on energy consumption. According to key stakeholders, FISE is preparing to visit all households nationwide on the current beneficiary list to update their eligibility status.

EDEs report regularly to OSINERGMIN, which conducts regular audits every 1–3 months to monitor the following indicators: 1) Number of beneficiaries in the EDE catchment area, 2) Number of vouchers distributed, and 3) Number of distributed vouchers that are exchanged. EDEs regularly oversee the activity of the beneficiaries and LPG agents, primarily to ensure that LPG agents are not attempting to collect and cash in vouchers that were never distributed to beneficiaries, or exchange vouchers outside of their designated catchment areas. To achieve this goal, EDEs monitor the following indicators and report them to OSINERGMIN: number of vouchers exchanged by a single beneficiary in the same month, date and time of exchange, specific office/location of distributor where exchange occurred, name of person who exchanged the voucher, and names of beneficiaries who have not exchanged a voucher in a single month.

Local authorities and community members are also encouraged to report misuse of the LPG vouchers to FISE. The "Tukuy Rikuy" system (meaning "to observe carefully" in English) was developed by OSINERGMIN as a way for local authorities to report complaints or inconsistencies directly to OSINERGMIN by text message. This facility was put in place to centralize complaints and requests and reduce barriers to communication between communities and OSINERGMIN.

Piloting the electronic voucher system

FISE is currently overseeing several pilots in different districts to test the rollout of a cellphone-based voucher system, under which beneficiaries receive voucher codes on their personal cell phones. According to key stakeholders, this strategy was devised to avoid commercial sale and other misuse of the vouchers by LPG agents and facilitate the delivery of vouchers to participants, based on the fact that cell phone penetration has increased substantially. Large-scale uptake of this system may be limited until mobile phone coverage increases. Still, the hope is that this electronic voucher system will replace physical vouchers, to increase efficiency and reduce program costs. Under the electronic system, there would no longer be a need for distribution of paper vouchers, increasing the speed and ease of voucher distribution. Pilot testing of the electronic system is currently underway in Puno; additional pilots of the system are being conducted in Cusco and Huancavelica with other electricity distributors. However, a major challenge for this system is that it requires engagement from all four major cell phone carriers of Peru and participants must bear the costs associated with cell phone use. The expansion of the program and increasingly large network of LPG agents has presented additional challenges that may result in outsourcing of some of the administrative or operational activities.

Program cost and sustainability

The FISE LPG Access Promotion Program cost approximately $82.3 million dollars per year in 2014, but was fully funded by the surcharge system in place (APEC, 2014). In Table 5, we display cost scenarios to beneficiary households and to FISE implementers assuming FISE vouchers cover a half-cylinder refill, one full cylinder refill, and two

Table 5
Costing scenarios of increasing the value of LPG vouchers.[a]

Monthly costs under current voucher scheme (1/2 cylinder per month)				Projected costs of voucher for 1 cylinder per month				Projected costs of voucher for 2 cylinders per month (to support exclusive use)			
Cost to beneficiary		Cost to FISE		Cost to beneficiary		Cost to FISE		Cost to beneficiary		Cost to FISE	
1 cylinder purchased/month	2 cylinders/month	Per HH	Total	1 cylinder/month	2 cylinders/month	Per HH	Total	2 cylinders/month	Per HH	Total
S./18	S./52	S./16	S./25.1 million	S./0	S./34	S./34	S./53.3 million	S./0	S./68	S./106.5 million
USD 5.54	USD 16.00	USD 4.92	USD 7.7 million	USD 0	USD 10.46	USD 10.46	USD 16.4 million	USD 0	USD 20.92	USD 32.77 million

[a] Assuming a 10 kg tank of LPG costs 34 soles (10.46 USD). Total costs to FISE calculated by multiplying the household cost by total number of registered FISE households as of October 2017 (1,566,587).

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full cylinder refills. Assuming no change in the current price of LPG tanks, supporting exclusive use (approximately two cylinders per month) to all currently registered beneficiaries (both active and inactive) would cost an additional $25.1 million dollars a month to FISE.

Discussion

The results of this evaluation show that the FISE LPG promotion program has achieved high geographical reach. There is some indication that the program may be reaching households with access to electricity at a higher level than households without electricity. In a sample of households, beneficiary households had lower kitchen HAP exposures than non-beneficiary households ($PM_{2.5}$). However, personal exposures did not differ between groups, and kitchen and personal exposures were consistently above the WHO interim air quality target. Sampled houses were located in low-density farming areas with minimal ambient air pollution and little use of other common sources of indoor air pollution, such as kerosene lamps and tobacco, suggesting that the HAP samples overwhelmingly represent pollution from cookstoves and not additional sources. While there is some indication that FISE has facilitated initial adoption of LPG stoves, stove stacking with biomass fuels was reported in >90% of beneficiaries. Community members in rural Puno described several barriers related to the complexity of the enrollment process and access to LPG distribution points; still, FISE participants expressed high satisfaction and desire to continue in the program.

Our results show that the FISE LPG program has made significant progress toward its goal of improving access to clean energy to Peruvians living in poverty. However, our survey results suggest that there is a significant proportion of households (~40%) who may be likely eligible for the program but have never participated. In Puno, the program appears to have reached households with electricity better than those without electricity. The likely reason for this is that electricity distributors have greater access to existing customers, and thus prioritized rollout of the program to these households. It is also possible that families living in remote areas with more limited access to electricity have less access to knowledge about the program. There is also a common misperception within the community that only households with electricity are eligible. Thus, FISE implementers should make a focused effort to enroll households without electricity and to clarify this misperception in marketing campaigns and communication strategies.

FISE's use of a targeted subsidy allows the program to avoid the problems traditionally associated with universal subsidies, which are well-documented to disproportionately benefit the wealthy. Targeted subsidies are also known to be more effective and efficient in promoting the transition to clean fuels (Troncoso & Soares de Silva, 2017). However, one of the most important challenges to implementing targeted subsidies is ensuring that they reach the intended population, preventing “leakage” to non-target populations, and avoiding smuggling and fraud on the part of vendors. The FISE LPG program leverages existing targeting systems such as SISFOH in crafting eligibility criteria, allowing the program to identify and target the poorest households in Peru. OSINERGMIN's multi-tiered monitoring system, much of which is text-message based, allows for the gathering of continuous feedback regarding voucher use and eligibility among beneficiaries, as well as indicators of voucher misuse among LPG agents. While FISE's targeting system facilitates program efficiency and consequently a more sustainable subsidy model, it has limitations. For example, limiting the program to households consuming <30 kWh monthly of electricity may place families living in multi-family households at a disadvantage. In addition, any changes in eligibility status can easily lead to confusion around eligibility and mistrust of FISE implementers if the reasons for these changes are not effectively communicated.

Our results show that FISE beneficiaries in Puno were overwhelmingly more likely to be currently using LPG stoves as compared to non-beneficiaries. Beneficiaries reported using LPG to cook an average of 60% of weekly meals, and most FISE beneficiaries reported using exclusively biomass stoves prior to making the decision to enroll in the program. These data suggest that FISE has facilitated initial adoption of LPG stoves in Puno. However, exclusive adoption of LPG was rare, with >90% of FISE beneficiary households reporting current stove stacking with biomass fuels. Kitchen and personal exposure concentrations reflected the high levels of stove stacking, with 48-hour mean concentrations exceeding WHO air quality standards (WHO, 2014). Use of kerosene for lighting is extremely low in Puno and in Peru as a whole; indeed, only 1.2% of Puno residents use kerosene for lighting according to the 2014 DHS survey (DHS, 2014). Rather, the majority (80.8%) use electricity, and those without electricity primarily use candles for lighting (14.3%). Our data also indicate that access to electricity is high even in rural regions, with 88.5% of households in the survey reporting that their household has access to electricity. Thus, adoption of LPG for cooking in combination with the already common use of electricity for lighting has the potential to ensure that total household energy use is clean. To make progress toward achieving the potential health benefits of clean fuels, FISE should incorporate strategies that address key barriers to exclusive use of LPG. Making effective and feasible changes to promote exclusive adoption could facilitate overall progress toward national targets such as the Sustainable Development Goals (Rosenthal, Quinn, Grieshop, Pillarisetti, & Glass, 2018).

Barriers to exclusive adoption of clean fuel technologies have been well-documented in the literature (Puzzolo et al., 2016). Cost is perhaps the most widely recognized barrier to achieving exclusive adoption of LPG, and subsidies are a commonly used strategy for improving adoption of clean fuels worldwide (Goodwin et al., 2014). One of the key contributors to the high levels of stove stacking in FISE beneficiary households may be that the current voucher is insufficient to support exclusive LPG use. Indeed, our estimates suggest that the voucher only supports approximately one quarter of domestic clean energy needs. One option for addressing this issue is to promote and support strategies for reducing fuel consumption at the household level to reduce the direct costs associated with LPG use. These strategies could include reducing the practice of cooking for animals such as pigs and dogs, using alternative methods for heating water for cleaning and bathing, training cooks to use the lowest flames possible, ensuring cooking ingredients are prepared in advance to prevent delays once the stove is lit, and promoting use of the most efficient pots and gas stove models. Another option is to increase the value of the monthly LPG vouchers to completely cover one or two tanks per month, or to create a sliding scale for the value of the voucher, in which the poorest households pay less. However, the feasibility and sustainability of such a change would likely depend on reducing the total number of beneficiaries, a substantial change in FISE's financing mechanism, or strong political will on the part of the Peruvian government to fund such an increase. Currently, key stakeholder interviews indicate that an increase in the voucher value is unlikely, as this would reduce the ability of the program to achieve their goal of increasing program reach.

Reducing the indirect costs and mitigating the challenges associated with obtaining LPG through the FISE program will also be key for achieving higher levels of exclusive LPG adoption and reducing stove stacking. Despite the considerably large network of LPG agents present in Puno, physical access is still a commonly-cited problem among beneficiaries, and one of the key reasons for not participating in the program among non-beneficiaries. One potential solution is the expansion or strengthening of the existing mobile LPG agent network. Another possibility is to consider incentivizing an LPG home delivery program, which has shown to be important for the sustainability of LPG use in a national program in India (Rajakutty et al., 2002; Troncoso & Soares de Silva, 2017). This service would be particularly beneficial to elderly and disabled individuals, or families living in remote areas. According to key stakeholders, OSINERGMIN is currently considering the possibility of introducing smaller (5 kg) LPG cylinders to increase portability

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and reduce upfront costs for poor households. This strategy has been carried out in Indonesia and is credited with improving LPG adoption among low and middle-income households in Senegal (Kojima, 2013; Toft, Beaton, & Lontoh, 2016; Troncoso & Soares de Silva, 2017). One facilitator to adoption of LPG stoves in Peru is that the foods traditionally cooked in rural areas do not require any special equipment or features, such as the "plancha" stoves in Mexico. This fact makes it easier to design an LPG stove that is acceptable and appropriate for use in this region.

The cost of alternative fuels is another key factor influencing stove stacking. While Puno as a region is not rich in natural sources of wood, the availability varies locally by community. Individuals living in wood scarce communities do need to purchase wood, although these families often opt to use dung as a no-cost alternative. As a result, in Puno and most rural areas of Peru, the most commonly used alternative fuels are dung and agricultural waste, materials that are generally free and abundant. Peru therefore differs from other countries where more expensive fuels such as charcoal or kerosene are the main alternative domestic energy sources. Implementing effective strategies for disadoption of biomass fuels may thus be particularly important in such settings where lower cost or free alternative options are readily available. Potential strategies for mitigating this challenge include providing incentives for removal of traditional stoves from households, and emphasizing the negative effects of cooking with biomass beyond health-related concerns, particularly targeting children as potential influencers of their parents' behavior. Other strategies could include recruiting early adopters or opinion leaders to change social norms, targeting messaging based on specific needs and perceptions of the community or of the season in which the messages are delivered, and conducting cooking demonstrations to visibly show the benefits of gas and how to use it. Providing training on how to safely operate LPG stoves would also mitigate concerns about safety. Results also showed that communication about program requirements was often lacking or misunderstood, highlighting a need for FISE to adjust their marketing strategy to more clearly explain the enrollment criteria and process. Community leaders, health professionals, and FISE implementers should communicate a unified message about the health effects of biomass fuels and strategies to mitigate them. FISE leadership and program implementers should make an effort to improve collaboration with the health sector, as well as the ministries of health, housing, and education.

There were several strengths and limitations to our methods. By incorporating both national and regional data, we were able to achieve both breadth and depth to our analyses. Through our mixed methods design, we employed a variety of primary and secondary data sources, allowing for methodological triangulation. In addition, incorporating perspectives from community participants, program implementers, and program leadership allowed us to incorporate a variety of perspectives. An important limitation to this study was that the survey results were drawn from only one region of rural Peru and may not be generalizable to other rural areas of Peru, or to urban areas of Peru where the challenges faced by beneficiary households are likely very different. Our survey results were also subject to recall bias and social desirability bias; for example, survey respondents may report using more LPG and higher satisfaction with FISE so as to be viewed more favorably by the survey team. Finally, our survey captured a small number of non-FISE beneficiaries who also used a LPG stove, which reduces our power to make comparisons with other groups. Primary data collection efforts were also cross-sectional. Thus, we were not able to collect information on stove use over time, nor were we able to directly observe changes in fuel use practices upon initiation of the program. While our results did show differences in stove preferences in different seasons, further research into the effects of seasonality on fuel use and exposures over time is needed.

This evaluation of the FISE LPG promotion program offers several lessons for large-scale public clean fuel promotion programs. The FISE LPG program demonstrates the advantages of using targeted cross-subsidies with respect to efficiency, equity, and sustainability; the program also provides a useful model for continually monitoring voucher use and sale using a text message-based system for improved efficiency. FISE's financing structure, through surcharges on unregulated energy consumers, has allowed the program to be fully funded and sustainable. FISE is also an example of how public and private partners can work in conjunction to implement a large-scale program. However, further research is needed to understand the motivations and goals of private partners to initiate and sustain participation in such programs.

Despite these successes, this evaluation highlights the importance of further reducing the financial barriers to LPG adoption, which will be necessary to reduce stove stacking and fully realize the health benefits of using clean fuels. Our results also emphasize the need for effective communication channels between implementers and beneficiaries, as well as other strategies such as home or community delivery services that reduce the physical barriers to LPG acquisition in remote areas. Future research is needed to understand the effectiveness of specific behavior change strategies for encouraging adoption of LPG and disadoption of biomass fuels, as well as which strategies can be most effectively and feasibly implemented in large-scale programs such as FISE. Furthermore, while similar programs may appear to be effective in encouraging initial adoption of LPG, it remains unclear to what extent LPG use can be sustained at the household level after this financial support is removed.

Abbreviations

APEC	Asia-Pacific Economic Corporation
COPD	Chronic Obstructive Pulmonary Disease
EDE	Empresas de Distribución Eléctrica
FISE	Fondo de Inclusión Social Energética
INEI	Instituto Nacional de Estadística e Informática
LPG	Liquefied Petroleum Gas
MINEM	Ministerio de Energía y Minas
OSINERGMIN	Organismo Supervisor de la Inversión en Energía y Minería
$PM_{2.5}$	Particulate Matter in the <2.5 μm diameter range
RE-AIM	Reach, Effectiveness, Adoption, Implementation, Maintenance
WHO	World Health Organization

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Declarations of interest

None.

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