Energy for Sustainable Development xxx (2018) xxx–xxx

Contents lists available at ScienceDirect

Energy for Sustainable Development

Government policy, clean fuel access, and persistent fuel stacking in Ecuador☆

Carlos F. Gould [a,*], Samuel Schlesinger [b], Andres Ochoa Toasa [c], Mark Thurber [d], William F. Waters [e], Jay P. Graham [f], Darby W. Jack [a]

[a] Department of Environmental Health Science, Columbia University Mailman School of Public Health, New York, NY, USA
[b] Independent Consultant, Quito, Ecuador
[c] Columbia University School of International and Public Affairs, New York, NY, USA
[d] Walsh Environmental Scientists and Engineers, Quito, Ecuador
[e] Institute for Research in Health and Nutrition, Universidad San Francisco de Quito, Quito, Ecuador
[f] Public Health Institute, Oakland, California, USA

ARTICLE INFO

Article history:
Received 27 February 2018
Revised 29 May 2018
Accepted 29 May 2018
Available online xxxx

Keywords:
Liquefied petroleum gas
Induction stoves
National program
Energy transitions
Subsidies
Fuel stacking

ABSTRACT

After more than three decades of access to low-cost liquefied petroleum gas (LPG) financed by large direct government subsidies, >90% of Ecuadorian households cook primarily with LPG. Due to the large fiscal burden of the LPG subsidy, increases in electricity from hydropower, and other socio-political factors, the Government of Ecuador has launched a major induction stove program (PEC) to reduce the demand for LPG. We assess the effects of the LPG subsidies and PEC using government records, interviews, academic literature, newspaper reports, household surveys, and focus groups. Household surveys, conducted in rural, northern Ecuadorian households ($n = 383$), characterized cooking patterns and fuel access. Focus groups ($n = 6$) were carried out with a subset of surveyed households to better characterize survey findings. The LPG subsidy was developed as part of broad social support reforms in the early 1970s, without specific aims to reduce the health impacts of household air pollution from woodfuel or provide economic benefits as part of the transition to a clean cooking fuel. Nonetheless, the subsidy has resulted in nearly all Ecuadorian households cooking primarily with LPG. PEC has generated the sale of 740,000 induction stoves since its inception in 2014, short of the goal of 3.5 million. Among the rural households surveyed, LPG use, acceptance, and satisfaction was high, however, more than three-quarters of those surveyed reported weekly woodfuel use. Induction stove ownership (17%) and use as a primary cooking fuel (1%) was low among the rural households surveyed; furthermore, households owning induction stoves reported very low satisfaction with the stoves. Here we show that nationally-representative surveys reporting only "primary cooking fuel" use may underestimate solid fuel use as a supplemental household cooking energy, particularly in rural areas where fuel availability issues play a stronger role in decisions about what fuels to use.

Introduction

Ecuador offers a striking example of cooking fuel use dynamics in an emerging middle-income country where significant subsidies for liquefied petroleum gas (LPG) have been provided for nearly 40 years (Troncoso & Soares Da Silva, 2017). Ecuador's experience illustrates the potential benefits and pitfalls of sustained LPG subsidies. A 15 kg cylinder of LPG currently costs US$1.60[1] (retail), a price that has not changed since 2001, providing a per-15 kg cylinder subsidy of approximately $11.50 (Guillén & Robalino, 2016; Ministry of Hydrocarbons of Ecuador, 2015). Approximately 90% of Ecuadorian households now cook primarily with LPG. However, the fiscal burden of the subsidy is large; in 2014, the Government of Ecuador spent US$716 million (around 1% of GDP) subsidizing national LPG use.

Developed in part to create demand for Ecuador's growing hydroelectric capacity and to address the cost of LPG subsidies, the Ecuadorian government has launched *La Programa de Eficiencia Energética para la Cocción*

☆ Funding: The authors acknowledge support from the United States National Institute of General Medical Sciences R25 GM 62454 to CFG and R01 ES 024489 and the United States National Institutes of Health (NIH) Common Fund program for Global Health supported through the Clean Cooking Implementation Science Network.

* Corresponding author at: 11th Floor, Environmental Health Science Department, 722 W 168th Street, New York, NY 10027, USA.
E-mail address: c.gould@columbia.edu (C.F. Gould).

[1] All dollar amounts in manuscript text and figures refer to US Dollars. All prices are current prices (i.e., not inflation adjusted). Ecuador adopted the US Dollar as its official currency in 2000.

https://doi.org/10.1016/j.esd.2018.05.009

("The program for energy efficient cooking"; PEC), which is built around incentives to install and use induction stoves (Ministry of Electricity and Renewable Energy of Ecuador, 2014). Induction stoves work by passing an alternating current through an electromagnet; the resulting oscillating magnetic field generates heat in any pot made of magnetic material, which then heats the contents of the pot. Induction cookstoves are safe, non-polluting, highly efficient, and have been identified as a potential "leapfrog technology" in settings where biomass cooking is common (Banerjee, Prasad, Rehman, & Gill, 2016; Smith, 2014). PEC includes a consumer credit for stove purchase provided through state electric utilities and overseen by the Ministry of Electricity and Renewable Energy that allows participants to make monthly payments as part of their electricity bill. PEC participants also receive 80 kWh of electricity per month free—an amount projected to cover household cooking for a family of five.

Here, we evaluate the implementation of these policies, and assess the extent to which both the LPG subsidy and PEC have resulted in shifts to clean cooking.

Methods

Drawing on a literature review and interviews with key informants, we describe relevant national background information (*National context and energy trends*) and analyze national data to review patterns of clean fuel use across Ecuador (*Determinants of clean fuel use*). In the sections, *LPG Subsidy* (*1970s to Present*) and *Induction Stoves Program* (*2014 to Present*) we provide descriptions and assessments of each program. We then evaluate the actual impacts of the programs on rural households in northern Ecuador using surveys and focus group discussions in the section *Experiences with LPG and induction in rural communities*.

Analysis of nationally representative data

We utilized the decennial census (1974, 1982, 1990, 2001, 2010, and 2014) to characterize the distribution of clean cooking fuel use (National Institute for Statistics and Census of Ecuador, 2017a). To assess the determinants of clean cooking fuel use throughout Ecuador, we analyzed the National Survey of Employment, Unemployment, and Underemployment, a nationally-representative survey with household-level data available every four months from 2007 to 2017 (National Institute for Statistics and Census of Ecuador, 2017b). In this dataset, we dichotomized the outcome variable "primary fuel used for cooking" as clean fuel (i.e., LPG or electricity) or solid fuel (e.g., woodfuel) and included a number of covariates in multivariable logistic regressions: 1) household income (log transformed); 2) rural or urban; 3) poor; 4) extremely poor; 5) household receives government conditional cash transfer (Bono de Desarrollo Humano); 6) household receives remittances; 7) presence of a child <5 years old in the household; 8) presence of a child 5–18 years old; 9) presence of elderly adult (>65 years old) in the household; 10) presence of a female in the household; 11) ethnicity reported as indigenous; and 12) ethnicity reported as afro-Ecuadorian. Separate analyses were conducted using data from two time frames—December 2008 (n = 17,438), and combined surveys from December 2015–March 2017 (excluding March and June 2016 due to corrupted data files) (n = 81,480)—to compare statistical relationships over time and because the selected surveys included all desired study variables.

Interviews with key informants

We carried out a series of interviews with current and former actors in the LPG and electricity sectors to fill in gaps in the literature and to gain a better understanding of current and historical drivers of LPG subsidies and PEC. The interviews were used to clarify the rationale for public policy decisions and processes. Seven interviews with nine key informants were undertaken in total by one to two researchers (SS, MT, or CG). Interviews lasted from one to four hours and were not recorded in order to encourage candid responses.

Household surveys

Fieldwork was conducted between August and October 2017 in three rural communities in the northern province of Carchi. We selected Carchi because it was home to a pilot program that promoted induction stoves between 2009 and 2013 (*Plan Fronteras*). The survey obtained information on households' current cooking practices and their perceptions and preferences of different cooking fuel options.

We asked participants to name all stoves and fuels used in an average week, as well as the frequency of use and the meals cooked with each fuel. In addition, participants described the benefits and limitations of each of their stoves. Fuel cost (Beltramo, Blalock, Levine, & Simons, 2015; Puzzolo, Pope, Stanistreet, Rehfuess, & Bruce, 2016), fuel availability (Lewis & Pattanayak, 2012; Puzzolo, Pope, Stanistreet, Rehfuess, & Bruce, 2016), heating demand (Aggarwal & Chandel, 2004; Granderson, Sandhu, Vasquez, Ramirez, & Smith, 2009; Hollada et al., 2017; Simon, Bailis, Baumgartner, Hyman, & Laurent, 2014), and fuel and stove compatibility with local cooking customs (Baumgartner et al., 2011; Terrado, Eitel, McCracken, & Charron, 2005) were studied as barriers to exclusive clean fuel use in household surveys. The survey was pilot tested and refined by the authors and the field team prior to implementation in order to improve clarity and respond to themes that emerged.

Focus group discussions

Following completion of the survey phase (September 2017), focus group discussions were conducted in the same communities to more fully understand knowledge, attitudes, and practices, especially regarding observed multiple cooking fuel use practices. Primary cooks were purposively sampled from surveyed households to elucidate perceptions related to the use of solid fuel, LPG, and induction stoves. We oversampled to include households that had purchased an induction stove through PEC. Focus group discussions were conducted by two researchers and a community liaison. Participants were offered a $5 cash incentive to cover transportation costs and for their participation.

Focus group discussions were semi-structured and included prompts to elicit an open-ended conversation about fuel use decision-making, barriers to exclusive LPG use, and perceptions of induction stoves. Open-ended questions were included to address economic, cultural, and psychological factors relevant to cooking practices and fuel choices. The focus group guide was pretested with two community members and modified based on feedback to improve clarity, flow, and face validity of the questions.

Focus group discussions were digitally recorded using a handheld device and subsequently transcribed. The analysis, led by one researcher (WW), was based on a three-stop coding procedure to elucidate emergent major dimensions of the focus group discussions (Corbin & Strauss, 1990).

Ethical considerations

This study was reviewed and approved prior to initiation of the research by the Institutional Review Boards (IRB) at the Columbia University Medical Center and the Universidad de San Francisco de Quito. All study participants provided written consent.

Results

National context and energy trends

Ecuador background

Ecuador is an upper middle-income country with a population of about 16 million and a 2016 GDP per capita of just over $6000.

Please cite this article as: Gould, C.F., et al., Government policy, clean fuel access, and persistent fuel stacking in Ecuador, *Energy Sustain Dev* (2018), https://doi.org/10.1016/j.esd.2018.05.009