Understanding Households' Choice of Cooking Fuels: Evidence from Urban Households in Pakistan

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Households in developing countries predominantly rely on solid fuel for cooking, which is injurious to both the environment and human health. The provision of clean energy for cooking, therefore, is essential for safeguarding the environment and human health, primarily of women and children in developing countries. Using the 2014–2015 Pakistan Social and Living Standards Measurement Survey and robust econometric methods, this study analyzes different types of energy used for cooking among urban households in Pakistan. The study shows that although urban households in Pakistan mostly use gas for cooking, the use of solid fuels, particularly among poor and relatively less educated households, is pervasive. The econometric findings confirm that households with a higher level of education and wealthy families mainly use clean energy, such as gas, and are less likely to use dirty solid fuels, such as cake dung and crop residue for cooking. Considering the expansion of middle-class households and anticipating their demand for clean fuel for cooking, this study suggests ensuring an adequate supply of clean sources of energy to meet future demand as well as augmenting the affordability and awareness among households who are still dependent on solid fuels.

Keywords: choice, cooking fuels, education, gas, Pakistan, solid fuels, wealth
JEL codes: D10, I31, Q40

I. Introduction

Globally, about 1.1 billion people do not have access to electricity, about 2.8 billion people lack access to clean cooking fuel, and 2.5 billion people use solid biomass for cooking purposes (International Energy Agency 2017). The hazardous impacts of indoor air pollution from the use of fuelwood and other solid fuels have

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Asian Development Review, vol. 37, no. 1, pp. 185–212
https://doi.org/10.1162/adev_a_00146

been widely documented (Lelieveld, Haines, and Pozzer 2018; Nie, Sousa-Poza, and Xue 2016; Rahut, Ali, and Behera 2016; World Health Organization 2018; Ezzati and Kammen 2002). Moreover, substantial use of fuelwood for cooking has been significantly adding to global carbon emissions (Akpalu, Dasmani, and Aglobitse 2011; Duflo, Greenstone, and Hanna 2008). Given the negative impacts of using solid fuel on both human health and the environment, it is essential to ensure the provision of clean fuels at a reasonable price to safeguard the environment, secure better health, and contribute to sustainable development. Sustainable development is clearly interconnected with the quality of household energy consumption (AGECC 2010). Lack of access to affordable, clean, and reliable energy sources is the leading cause of excessive use of solid fuels in many developing countries, particularly in South Asia and sub-Saharan Africa (Behera et al. 2015; Rahut et al. 2014; Rahut, Mottaleb, Ali, and Aryal 2017; Rahut, Behera, Ali, and Marenya 2017; Rahut, Behera, and Ali 2016b, 2017; Mottaleb, Rahut, and Ali 2017).

The energy ladder hypothesis (Leach 1975, 1992) explains the relationship between income or wealth and the types of energy used. The energy ladder ranks fuel according to quality, ease of use, and price, from solid fuels such as wood and coal at the bottom, liquid fuels such as gas and kerosene in the middle, and finally, electricity at the top (Leach 1992, 1975). The use of wood, cow dung, and crop residue is common among poor households in South Asia, while more affluent households use electricity, gas, and liquid petroleum gas (LPG) (Behera et al. 2015). The energy ladder hypothesis assumes that in response to an increase in income, families will move away from biomass and other solid fuels to more efficient fuels such as LPG, gas, and electricity. However, studies in Mexico and other places have found that, due to energy stacking or the use of multiple energy sources, energy transition is a complex phenomenon (van der Kroon, Brouwer, and van Beukering 2013; Masera, Saatkamp, and Kammen 2000).

The ladder-within-a-ladder energy hypothesis explicates the transition in electricity use from only lighting to include other uses such as cooking (Rahut, Mottaleb, Ali, and Aryal 2017; Rahut, Behera, Ali, and Marenya 2017) and thus can elucidate the more complex behavior in energy transition than in the simple energy ladder hypothesis, which shows the link between energy choice and income (Leach 1975, 1992). The central engine influencing the movement up the energy ladder is theorized to be the level of household income and relative fuel prices (Barnes, Krutilla, and Hyde 2010; Leach 1992; Barnes and Floor 1999; Rahut et al. 2014). Together with the expenditure on energy, the category of energy employed varies with income (Rao and Reddy 2007), with a shift to contemporary clean fuels (Daioglou, van Ruijven, and van Vuuren 2012), in particular, the use of electricity increases with income (Hills 1994). Poor households are inclined to use solid fuels for domestic purposes, which are harmful to the environment and human health (Rehfuess, Mehta, and Prüss-Üstün 2006; Bruce, Perez-Padilla, and Albalak 2000;

Holdren et al. 2000), but when their income rises, households usually, but not always, shift to cleaner fuels (Masera, Saatkamp, and Kammen 2000; Nansaior et al. 2011).

The energy ladder and the factors influencing a household's decision to switch to cleaner fuels when household income increases has been documented in many developing countries (Özcan, Gülay, and Üçdoğruk 2013; Karimu 2015; Rahut, Behera, Ali, and Marenya 2017; Mottaleb, Rahut, and Ali 2017; Hou et al. 2017; Rahut, Ali, and Mottaleb 2017). Moreover, family demographic characteristics, habits, and gender of the household head play important roles in a household's choice of fuel for cooking. Thus, ascertaining the relative significance of the above factors that affect a household's fuel choice for cooking is critical for policy making in the context of Pakistan.

With a population of 197 million and an annual gross domestic product (GDP) per capita of $1,547 in 2017, Pakistan is one of the most urbanized countries in South Asia, where 38.3% of the total population resides in urban areas (World Bank 2019). Importantly, it is projected that by 2050, the population of Pakistan will be between 276 million and 344 million (depending on the assumption of the fertility rate), of which 52.2% will be residing in urban areas (UN DESA 2015). With this background, it is useful to understand the fuel choice behavior of urban households, which is an underresearched subject in Pakistan. The commonly available fuel choices among urban households are gas, LPG, fuelwood, and animal dung. However, a small number of urban households also use kerosene oil and electricity as the primary source of cooking fuel. Planned urban areas mostly use gas, whereas slum areas mostly use fuelwood and gas. Most urban households use gas, which is connected through pipes, and a small number use LPG. The dataset used for this study does not distinguish between gas and LPG. Irrespective of whether it is gas or LPG, both are assumed to be clean sources of energy from the user's perspective.

This study contributes to the existing research in several ways. First, it uses a large, nationally representative dataset from Pakistan from over 13,965 households in urban areas. The data represent all four major provinces of Pakistan—Balochistan, Khyber Pakhtunkhwa, Punjab, and Sindh. Second, to our knowledge, this is the first attempt to study the patterns and determinants of cooking fuel use of urban households in Pakistan. Third, ordered probit econometrics are used to analyze the factors determining the household's choice of fuel. Fourth, the study uses different indicators of wealth and education to confirm the effect of these factors on fuel choice. Finally, as the dataset encompasses a large number of variables, the study enabled us to conduct several robustness tests on the role of household education at different levels and wealth on fuel choice behavior.

The rest of the paper is organized as follows. Section II provides a review of relevant literature, while section III contains a background of Pakistan with a focus on energy use, population growth, and level of income growth between 1990 and

2014. Section IV explains the sampling methods, data, and methodology applied in the study. Section V presents the findings of the study with some discussions of the results. Section VI concludes the study and includes some policy implications and recommendations.

II. Literature Review

In the past, a number of studies have focused on household fuel use behavior. Some studies in South Asia have found that household income or poverty, wealth, family size and composition, and gender influence the households' choice of energy (Yasmin and Grundmann 2019; Nasir, Murtaza, and Colbeck 2015; Aryal et al. 2019; Mottaleb, Rahut, and Ali 2017; Rao and Reddy 2007; Khandker, Barnes, and Samad 2012). Since clean fuels are more convenient to use, households obtain more utility from their use compared to dirty fuels, and thus they are more willing to pay for clean fuel. As a result, households with more wealth are more likely to shift to clean fuel. As income increases, households in India tend to change to clean sources of fuel instead of using solid fuel such as fuelwood, dung cake, and crop residue (Rao and Reddy 2007). The demand for energy increases with an increase in total per capita consumption in India (Pachauri et al. 2004).

Education plays an important role in the use of clean energy for cooking purposes in mainly two ways: (i) human capital increases earnings, which leads to increases in purchasing power and the value of time; and (ii) education increases awareness, which in turn affects preferences. Households whose head of the family has a higher level of education are more reliant on clean and efficient fuel (Rao and Reddy 2007). The number of educated female members between 10 and 50 years old is positively associated with the choice of clean fuel (Pandey and Chaubal 2011). The education of household heads and their spouses positively influences the use of modern and clean fuel, as these provide notable savings of time which could be used for leisure and other productive employment (Reddy and Srinivas 2009). The level of education is positively related with the use of clean and modern fuel and negatively associated with the use of solid fuel (Rahut, Behera, and Ali 2017; Rahut, Ali, and Mottaleb 2017; Mottaleb, Rahut, and Ali 2017; Heltberg 2004).

A study in Bolivia found that the education and income of female household members led to a reduction in the use of fuelwood and other solid fuels (Israel 2002) because education increases awareness about the benefits and costs of using clean fuels. In developing countries, female members are mostly involved in fuelwood collection and cooking (Heltberg, Arndt, and Sekhar 2000), hence when females take the decision-making role in the household, the inclination to use clean and modern fuel increases. Conversely, a global study found that financial reward drives the collection of fuelwood rather than the cultural norm that women collect fuelwood (Cooke, Köhlin, and Hyde 2008). Family size also matters. With more family members, the labor available for collecting fuelwood increases and energy needs also increase, such that a negative relationship was noted between household size and use of clean cooking fuel (Pandey and Chaubal 2011).

Against the backdrop of increasing urbanization, limited studies on household fuel use behavior in urban Pakistan, and the adverse health impact from the use of solid fuel, this study empirically explores the factors that actually drive the choice of cooking fuel among urban households in Pakistan.

III. Background

Pakistan is a developing South Asian nation surrounded by the Arabian Sea in the south, Afghanistan and Iran in the west, the People's Republic of China in the north, and India in the east. The country is divided into four major provinces: Balochistan, Khyber Pakhtunkhwa, Punjab, and Sindh.

GDP at current prices grew sixfold from $40 billion in 1990 to $244.4 billion in 2014. During the same period, GDP per capita has increased from $371.6 to $1,317 (Table 1). The population of Pakistan increased from 107.7 million in 1990 to 185.5 million in 2014 with an annual growth rate of over 2.1%. Data show the gradual urbanization of Pakistan: the urban population gradually increased from 30.6% in 1990 to 38.3% in 2014, while the rural population declined from 69.4% to 61.7%. During the last 2.5 decades, energy use (kilograms of oil equivalent per capita) increased by only 22%, while electric power consumption (kilowatt-hours per capita) increased by about 70%. The percentage of urban population with access to electricity increased significantly from 94.4% in 1995 to 100% in 2014, while the percentage of the rural population with access to electricity increased from 54.4% to 95.6%. The percentage of the population with access to clean cooking fuels and technologies rose from 23.8% in 2000 to 44.8% in 2014.

Harnessing existing renewable energy sources is of paramount importance as Pakistan faces a severe shortage of energy (Chaudhry, Raza, and Hayat 2009). Limited fossil fuel resources and a poor economy, which limits the purchase of fossil fuels in large quantities from abroad, are the leading causes of undersupply and the lack of access to clean sources of energy for Pakistani households. Biomass is a primary source of energy, and it provides 36% of the total energy supply (Asif 2009). Hence, it is essential for Pakistan to stimulate investment in readily available home-grown sources of clean energy such as solar, hydropower, and wind.

In 2008, the gap between supply and demand of electricity in Pakistan stood at 4,500 megawatts (Asif 2009). Pakistan produces much less than its actual potential in the hydropower sector, having the potential for more than 42 gigawatts, out of which only 6.5 gigawatts have been utilized. The annual radiant flux (power) received by a surface per unit area in Pakistan is 1,900 to 2,200 kilowatt-hours per square meter, making it one of the highest solar insolation in the world, which can be exploited to generate electricity and supply to off-grid households in Pakistan.

Table 1. **Electricity Access Rate**

Indicator	1990	1995	2000	2005	2010	2014
			Economy			
GDP (current $ million)	40.0	60.6	74.0	109.5	177.4	244.4
GDP per capita (current $)	371.6	493.7	533.9	711.5	1,040.1	1,317.0
GDP growth (annual %)	4.5	5.0	4.3	7.7	1.6	4.7
			Population			
Total population (million)	107.7	122.8	138.5	153.9	170.6	185.5
Urban population (% of total)	30.6	31.8	33.2	34.7	36.6	38.3
Rural population (% of total)	69.4	68.2	66.8	65.3	63.4	61.7
Population growth (annual %)	2.9	2.5	2.3	2.1	2.1	2.1
Urban population growth (annual %)	3.7	3.3	3.1	3.0	3.2	3.3
Rural population growth (annual %)	2.6	2.2	1.9	1.5	1.5	1.4
			Energy use			
Energy use per capita (kilograms of oil equivalent)	398.4	435.9	462.5	497.1	498.5	484.4
Electric power consumption (kilowatt-hours per capita)	277.4	357.9	372.4	463.1	465.2	471.0
			Access to electricity			
Access to electricity (% of population)	58.7	67.1	75.2	83.9	91.0	97.5
Access to electricity, urban (% of urban population)	…	94.4	95.5	96.4	98.6	100.0
Access to electricity, rural (% of rural population)	43.3	54.4	65.1	74.3	86.6	95.6
Access to clean fuels and equipment for cooking (% of population)	…	…	23.8	31.5	38.9	44.8

GDP = gross domestic product.
Sources: United Nations. http://data.un.org; World Bank. https://data.worldbank.org/indicator (both accessed June 2018).

Besides the generation of electricity, solar energy has numerous direct applications like water heaters and stoves (Mirza, Maroto-Valer, and Ahmad 2003).

Wind power is also an important source of clean and renewable energy. Pakistan has enormous potential to harness wind energy: the coastline in the south stretches more than 1,000 kilometers, and some mountainous regions in the north are gifted with an excellent source of wind energy, which can be harnessed to generate electricity. A study in Pakistan found that enormous potential for harnessing wind energy exists, but considerable efforts are required to successfully utilize this cheap, clean, and renewable energy source (Mirza et al. 2007).

Table 2 provides summary statistics on energy production and consumption by major sources during the last 2.5 decades. Total kerosene consumption declined from 1,132 thousand metric tons (MT) in 1990 to 182 thousand MT in 2014, while the consumption of fuelwood increased from 20,701 thousand cubic meters (m^3) in 1990 to 29,053 thousand m^3 in 2014, which is entirely consumed by households. The consumption of charcoal does not show any particular trend, but the total

Table 2. **Energy and Fuels in Pakistan**

	1990	1995	2000	2005	2010	2014
	Other kerosene (thousand metric tons)					
Production	411	463	286	209	122	182
Consumption by households	1,117	585	461	129	85	103
Final consumption	1,132	603	494	236	162	182
	Fuelwood (thousand cubic meters)					
Production	21,043	22,683	30,880	26,500	29,660	29,533
Consumption by households	20,701	22,023	30,550	26,116	29,226	29,053
Final consumption	20,701	22,023	30,550	26,116	29,226	29,053
	Charcoal (thousand cubic meters)					
Production	57	110	55	64	72	80
Consumption by households	57	110	55	64	72	80
Final consumption	57	110	55	64	72	80
	Liquefied petroleum gas (thousand cubic meters)					
Production	127	128	206	558	432	469
Consumption by households	95	128	179	385	259	245
Final consumption	127	171	239	578	465	562
	Electricity (million kilowatt-hours)					
Gross production	37,660	53,555	65,760	93,629	94,383	105,305
Combustible fuels	20,442	30,186	46,064	60,283	59,152	68,390
Hydro	16,925	22,858	19,288	30,862	31,811	31,428
Nuclear	293	511	399	2,484	3,420	5,090
Wind						397
Net production	36,577	51,811	63,120	89,963	92,144	101,504
Imports				146	269	428
Own use by electricity, heat, and CHP plants	1,083	1,744	2,640	3,666	2,239	3,801
Losses	7,808	12,191	17,553	22,506	15,315	18,333

CHP = combined heat and power.
Source: United Nations. http://data.un.org (accessed June 2018).

charcoal consumption has increased from 57 thousand MT to 80 thousand MT, and households consume 100% of it. The production and consumption of gas have grown considerably during the last 30 years. Gross electricity production increased 2.8 times from 37,660 million kilowatt-hours (kWh) in 1990 to 105,305 million kWh in 2014. The share of hydropower in electricity generation has gradually declined and currently stands at 30%.

In general, in developing countries like Pakistan, the fuel market is completely controlled and managed by the government. This means that prices of fuel are not derived from the interaction of supply and demand but are fixed by the government. A study in Pakistan found that fuel consumption is highly price inelastic (Burney and Akhtar 1990). Hence, we do not see much variation in fuel prices across the region. In addition, the datasets used for our current research do

Table 3. **Fuel Prices**

	2014	2015	2016	2017	2018	Source
Fuelwood (PRs/kg)	32	35	34	38	37	Different sources
Kerosene (PRs/liter)	57	56	48	66	85.3	OGRA
Electricity (PRs/unit)	15	16	16	17	18	NEPRA and other sources
LPG (PRs/kg)	130	133	125	118	112	OGRA

kg = kilogram, LPG = liquid petroleum gas, NEPRA = National Electric Power Regulatory Authority, OGRA = Oil and Gas Regulatory Authority, PRs = Pakistan rupees.
Sources: National Electric Power Regulatory Authority; Oil and Gas Regulatory Authority.

not have information on prices of fuel; hence, we do not use the price variable in the model. As fuelwood is not sold in an established market, it is difficult to determine its price (Cooke, Köhlin, and Hyde 2008).

Secondary data in Table 3 show that the price of fuelwood was around 37 Pakistan rupees (PRs) per kilogram (kg) in 2018, and during the last 5 years (between 2014 and 2018), it ranged from PRs32 to PRs38 with a steady increasing trend. The price of kerosene has increased sharply over the years to PRs85 in 2018. Kerosene use declines with increases in income and education of households and household heads (Rahut, Behera, and Ali 2016a; Rahut et al. 2014). The use of kerosene in Pakistan has been declining over the years. For example, in 1986, daily use of kerosene was 19 thousand barrels but has declined to 13 thousand barrels in 1996 and 3.5 thousand barrels in 2012 (IndexMundi 2018). This is mainly due to the availability of LPG and an increase in the price of kerosene. In the past, most urban households did not have access to gas. But over the years, access to gas has been increasing, hence replacing the use of kerosene oil in cities. The unit price of electricity was PRs18 in 2018 and has remained relatively constant during the last 5 years. The price of LPG has marginally declined over the years. A kilogram of LPG was about PRs112 in 2018.

In urban areas, 86% of fuelwood are purchased, whereas in rural areas, only 31% are purchased while the rest are mostly collected by women and children (World Health Organization 2005). Hence, there is a little scope to discuss the role of women and children in collecting fuelwood in urban areas of Pakistan, and the datasets do not provide information on fuelwood collection (World Health Organization 2005).

The energy crisis continues in Pakistan, and the availability of energy both for lighting and cooking is a serious issue. Although the majority of the urban population, especially in major cities, use gas for cooking, the availability of gas always remains an issue. As a result, people in urban and semi-urban areas turn to alternative energy sources like fuelwood and even animal dung and crop residue. Hence, this study explores the determinants of energy sources for cooking in urban areas of Pakistan using a large nationally representative dataset and provides some important policy implications.

Table 4. **Sample Distribution**

	Fixed for the Survey 2014–2015			Covered during the Survey 2014–2015		
	Urban	**Rural**	**Total**	**Urban**	**Rural**	**Total**
			Primary sampling units			
Balochistan[a]	140	670	810	137	591	728
Khyber Pakhtunkhwa	104	777	881	104	764	868
Punjab	594	1,860	2,454	594	1,860	2,454
Sindh	376	907	1,283	375	901	1,276
Total	**1,214**	**4,214**	**5,428**	**1,210**	**4,116**	**5,326**
			Secondary sampling units—Households			
Balochistan[a]	1,680	10,720	12,400	1,568	9,248	10,816
Khyber Pakhtunkhwa	1,248	12,432	13,680	1,184	11,898	13,082
Punjab	7,128	29,760	36,888	6,814	29,188	36,002
Sindh	4,512	14,512	19,024	4,399	14,336	18,735
Total	**14,568**	**67,424**	**81,992**	**13,965**	**64,670**	**78,635**

[a]Includes Islamabad and used as a base category.
Source: Pakistan Social and Living Standards Measurement Survey.

IV. Sampling, Data, and Methodology

A. Sampling and Data

This study uses the 2014–2015 Pakistan Social and Living Standards Measurement Survey to analyze the sources of energy for cooking fuel and their determinants. The current study is of great value as it is based on a nationally representative survey collected from all the four major provinces of Pakistan—Balochistan, Khyber Pakhtunkhwa, Punjab, and Sindh. The Pakistan Bureau of Statistics designed the sampling frame for both urban and rural areas. Every city and town is split into enumeration blocks comprising of 200–250 households. For rural areas, an updated list of villages (called *mouzas* or *dehs*) or their parts (blocks) based on the 2011 house listings is taken as a sampling frame. A two-stage stratified sampling methodology was used to sample households for the survey. Enumeration blocks were designated as primary sampling units (PSUs) for urban and rural domains. PSUs were sampled using the proportion-to-size (PPS) approach. The number of households in the enumeration blocks was taken as a measure of size for both rural and urban areas.

Households listed in the sampled PSUs were taken as the secondary sampling units (SSUs), and about 12 households from each urban sample SSU and 16 households from the sample PSUs were chosen with equal probability using a systematic random sampling method. Hence 5,428 sample blocks (PSUs) comprising 81,992 households (SSUs) were selected for the survey (Table 4). Among the households selected for the survey, 67,424 were from rural areas and 14,568 were from urban areas of Pakistan.

Owing to challenging circumstances in the Panjgur district of Balochistan, it was not included in the final survey. Additionally, 7 PSUs from Sindh, 13 PSUs from Khyber Pakhtunkhwa, and 82 PSUs from Balochistan were excluded from the final survey due to the security situation. From the selected 81,992 households, only 78,635 households (13,965 urban households and 64,670 rural households) were actually covered during the survey. As the number of households using kerosene oil and electricity were very small, we could not use this data for the analysis. Hence, we dropped 16 households who were using kerosene oil and two households who were using electricity, such that 13,947 sampled households were used for the study. We did not encounter the problem of missing observations, which could have been for three reasons. First, the variables used in the analysis were mostly from the household roster and categorical variables, which are easy for the enumerators to capture. Second, the enumerators might have been trained well to capture all the information. Third, the survey instrument was only 13 pages, capturing mostly simple and categorical information, which are easy to capture and review to follow up for missing variables.

B. Econometric Model Specifications: Ordered Probit

An ordered probit model is employed when the dependent variable has more than two outcomes and an ordinal scale. In this study, the explained variable is a family's ranking based on the types of fuel used for cooking, that is, a family that uses dung cake and crop residue as cooking fuels were graded at the lowest level followed by fuelwood; households that use gas were ranked at the highest level. The model is estimated using the maximum likelihood method as it cannot be consistently estimated using ordinary least squares due to the ordered nature of the explanatory variable.

Suppose the underlying association to be considered is

$$y^* = X'\beta + \varepsilon_i$$

where y^* is the exact but unobserved explained variable, X' is the vector of explanatory variables, and β is the vector of regression coefficients, which we wish to approximate. While we cannot observe y^*, we instead can only observe the following response categories:

$$\begin{cases} 0 & \text{if } y^* \leq 0, \\ 1 & \text{if } 0 < y^* \leq \mu_1 \\ 2 & \text{if } \mu_1 < y^* \leq \mu_2 \\ \vdots & \\ N & \text{if } \mu_{N-1} < y^* \end{cases}$$

Then the ordered probit method uses the observations on y, which is a form of censored data on y^*, to fit the parameter vector β. The variable y^* is a dependent variable which takes the value of 1, 2, and 3 depending on the ranking, which is described as

$y^* = 1$, if a household uses dung and crop residue as fuel for cooking;
$y^* = 2$, if a household uses fuelwood as fuel for cooking; and
$y^* = 3$, if a household uses gas as fuel for cooking.

In the equation, X' is a vector of explanatory variables that include the following:

(i) **Demographic**
- (a) Age of household head in years
- (b) Square of the age of household head in years to take nonlinearity into account (coefficient of age squared is multiplied by 1,000 to present the results in four decimal places)
- (c) A gender or sex dummy that assumes a value of 1 if the household head is a female and 0 otherwise
- (d) Household size measured by the number of family members (in addition, in an alternate specification of the model, we used number of children [<=15 years], number of adults [>15 years and <65 years], number of adult males and females [>15 years and <65 years], and number of elderly members [>=65 years])

(ii) **Education**
- (a) Below primary: a dummy that assumes a value of 1 if the household head is educated up to less than the primary level (<grade 5) or 0 otherwise
- (b) Primary completed: a dummy that assumes a value of 1 if the household head has completed the primary level but not middle school (>grade 5 and <grade 8) or 0 otherwise
- (c) Middle school completed: a dummy that assumes a value of 1 if the household head has completed middle school but not secondary school (>=grade 8 and <grade 10) or 0 otherwise
- (d) Secondary school completed: a dummy that assumes a value of 1 if the household head has completed secondary school but not senior secondary school (>=grade 10 and <grade 12) or 0 otherwise
- (e) Senior secondary school completed: a dummy that assumes a value of 1 if the household head has completed senior secondary school but not university (>=grade 12 but not completed university) or 0 otherwise
- (f) University completed: a dummy that assumes a value of 1 if the household head has completed university-level education or 0 otherwise
- (g) Illiterate dummy that assumes a value of 1 if the household head has not attended school or 0 otherwise (base category)

(h) In an alternate specification of the model, we used the average and maximum years of schooling of adults, adult males, and adult females; education of elderly members; and years of schooling of the household head and spouse. Households who do not have members in these groups (adults, adult males, adult females) were treated as missing observations instead of given a value of 0. Hence, the sample size in this alternate specification is lower.

(iii) **Wealth**

(a) We used PCA to compute a household assets index based on durable assets (flat iron, fan, sewing machine, radio, clock, television, video compact disc player, refrigerator, air cooler, air conditioner, computer, bicycle, motorcycle, car, truck, washing machine, microwave oven, and generator) owned by the household.

(b) In an alternative specification, we used roof and wall materials of the house and type of toilet as dependent variables.
- Cement and tin roof: a dummy that assumes a value of 1 if the roof of a house is made of cement, concrete, or tin, or 0 otherwise
- Toilet type: a dummy that assumes a value of 1 if no toilet or 0 otherwise; a dummy that assumes a value of 1 if there is a pit toilet or 0 otherwise; and a dummy that assumes a value of 1 if there is a flush toilet or 0 otherwise

(c) Agricultural land owned by the family (hectares)

(d) Value of nonagricultural land owned by the family (million PRs)

(e) Livestock assets: tropical livestock unit, which is based on weights of 0.7 for cattle, 0.2 for goats and sheep, and 0.01 for poultry

(f) Distance from household to high school (within 30 minutes from home)

(g) Location
- A dummy that assumes a value of 1 if the household is located in Khyber Pakhtunkhwa or 0 otherwise
- A dummy that assumes a value of 1 if the household is located in Punjab or 0 otherwise
- A dummy that assumes a value of 1 if the household is located in Sindh or 0 otherwise
- A dummy that assumes a value of 1 if the household is located in either Balochistan or Islamabad or 0 otherwise (base category)

Note that in reality, rural households, in particular, use more than one source of energy for cooking. For example, mostly in the dry season, households in rural areas use biomass such as leaves and branches for cooking, whereas in the wet and rainy season, they mostly rely on fuelwood and a kerosene stove or cooker. In general, in urban areas, the major sources of cooking fuel are electricity, LPG or gas, and fuelwood. Due to the existence of fuel stacking, especially with cooking fuel in rural areas in developing countries (Masera, Saatkamp, and Kammen 2000; van der Kroon, Brouwer, and van Beukering 2013), it would be interesting to examine the choice of multiple energy sources for cooking. Another study in India found that fuel stacking has decreased in lighting over time (Cheng and Urpelainen 2014). Fuel stacking is comparatively lower in urban areas. Unfortunately, the survey only captured information on major fuels used for cooking and essentially failed to capture the fuel-stacking behavior and the reliance on multiple sources of energy. Thus, this study cannot analyze a multivariate choice model that considers households' fuel-stacking behavior.

V. Findings and Discussions

A. Descriptive Findings

Table 5 provides descriptive statistics of the variables used in the empirical analysis. The mean age of the household head was 45 years, with little variation across different groups using gas, fuelwood, dung, and crop residue. Information about the household head's gender shows that females headed about 7% of the urban households. The average urban household size was about six, with variations across households that use different types of fuel. Very few family members were older than 65 years in the household, that is, only 0.2 on average. The number of children in a household was 2.6 on average, and the number of adults in the household was 3.6, with an almost equal proportion of adult males and females.

The average years of schooling of the urban household head was about 6.8, and it was highest for households using gas (7.7 years), while it was 4.5 years for households using fuelwood and 4 years for those using dung cake and crop residue. The overall education level of the spouse of the household head was about 4.2 years, with 5.2 years for households using gas, 1.8 for households using fuelwood, and 1.7 for those using dung cake and crop residue. For urban households, the mean education levels of both male and female adults was about 6.6 years, with the average level of education of adult males (7.7 years) slightly higher than females (5.4 years). The highest level of school attained by an adult member of the family was approximately 9.8 years on average. The maximum education of adults was higher for households using gas (10.9 years) than households using fuelwood (7.2 years) and dung cake and crop residue (6 years), and it was higher for males compared to females. The maximum education of the oldest members is higher for those households using gas (6.4 years) compared to 3.5 years for households using fuelwood and 2.8 years for households using cow dung and crop residue. The average years of schooling of adult males was higher than for adult females for all age categories, and the differences were statistically significant (see Appendix).

Table 5. **Descriptive Statistics of Variables Used in the Study for Urban Households**

	Total		Dung and Crop Residue		Fuelwood		Gas	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Demographic								
Age of household head	45.2	12.8	43.0	12.8	43.9	13.1	45.8	12.7
Female household head (dummy)	7%		9%		6%		8%	
Household size	6.4	3.0	6.4	2.8	6.5	3.0	6.3	3.0
Number of elderly (>65 years)	0.2	0.5	0.2	0.4	0.2	0.5	0.2	0.5
Number of children (<15 years)	2.6	2.1	2.9	2.0	3.0	2.2	2.4	2.0
Number of adult members (15–65 years)	3.6	2.0	3.3	1.9	3.3	1.8	3.7	2.0
Number of adult males (15–65 years)	1.8	1.2	1.6	1.1	1.7	1.2	1.8	1.3
Number of adult females (15–65 years)	1.8	1.1	1.7	1.1	1.7	1.0	1.8	1.1
Human capital (years of schooling)								
Education of the household head	6.8	5.6	4.0	4.9	4.5	5.0	7.7	5.5
Education of the spouse of the head	4.2	5.2	1.7	3.7	1.8	3.7	5.2	5.4
Mean education of adults by gender (years of schooling)								
Mean education of adults (15–65 years)	6.6	4.5	3.4	3.7	4.1	3.7	7.6	4.4
Mean education of male adults (15–65 years)	7.7	5.0	4.6	4.6	5.5	4.7	8.6	4.8
Mean education of female adults (15–65 years)	5.4	5.1	2.1	3.7	2.6	3.9	6.5	5.1
Maximum education of adults by gender (years of schooling)								
Maximum education of adults (15–65 years)	9.8	5.3	6.0	5.3	7.2	5.4	10.9	4.9
Maximum education of male adults (15 to 65 years)	9.0	5.4	5.6	5.1	6.6	5.3	9.9	5.1
Maximum education of female adults (15–65 years)	6.8	5.9	2.9	4.6	3.6	5.0	8.0	5.8
Education of the elderly (years of schooling)								
Mean education of the elderly (>65 years)	3.0	4.7	1.1	2.8	1.6	3.4	3.6	5.0
Maximum education of the elderly (>65 years)	3.3	5.0	1.1	2.8	1.8	3.7	4.0	5.3
Mean education of the oldest member	5.6	5.6	2.8	4.5	3.5	4.7	6.4	5.7
Household heads' education (percentage of households)								
No education (dummy)	30%		51%		47%		24%	
Below primary (dummy)	4%		6%		5%		3%	

Continued.

Table 5. *Continued.*

	Total		Dung and Crop Residue		Fuelwood		Gas	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Primary completed (dummy)	15%		16%		15%		15%	
Middle school completed (dummy)	11%		8%		9%		12%	
Secondary school completed (dummy)	17%		9%		12%		19%	
Senior secondary school completed (dummy)	9%		5%		6%		10%	
University completed (dummy)	14%		6%		5%		17%	
Wealth and assets								
Assets index	10.6	3.1	8.4	3.7	8.7	3.7	11.4	2.4
Agricultural land owned (hectares)	1.2	16.2	2.4	20.9	1. 0	5.6	1.3	18.2
Value of nonagricultural land owned (million Pakistan rupees)	1.7	3.3	0.9	1.4	0.9	1.7	2.0	3.7
Livestock assets index	0.6	3.08	1.1	2.9	1.3	4.7	0.3	2.2
No toilet (dummy)	1%		4%		4%		0.5%	
Pit toilet (dummy)	5%		14%		13%		2%	
Flush toilet (dummy)	94%		82%		83%		98%	
Brick-walled house (dummy)	91%		79%		75%		96%	
Cement and metal roof (dummy)	38%		17%		13%		48%	
Wood and bamboo roof (dummy)	62%		83%		87%		52%	
Mud, bamboo wall (dummy)	9%		21%		25%		4%	
Accessibility								
Distance to high school (within 30 minutes) (dummy)	98%		97%		96%		99%	
Distance to store (within 30 minutes) (dummy)	100%		99%		100%		100%	
Location: province								
Balochistan (dummy)	9%		10%		19%		6%	
Khyber Pakhtunkhwa (dummy)	8%		4%		10%		8%	
Punjab (dummy)	51%		52%		43%		53%	
Sindh (dummy)	32%		34%		28%		33%	

SD = standard deviation.
Source: Authors' calculations from the Pakistan Social and Living Standards Measurement Survey.

In urban areas, about 30% of the household heads did not go to school, 4% attended some primary school, 15% completed primary education, 11% completed middle school, 17% completed secondary school, 9% completed senior secondary school, and 14% completed university. About 50% of the households using dung cake and crop residue did not attend school, 47% of the households using fuelwood for cooking did not go to school, but only 24% of the households using gas did not attend school.

Using PCA, we constructed a wealth index for the urban households and found that the wealth index was much higher for households using gas than households using fuelwood, dung cake, and crop residue for cooking. The average agricultural land owned (hectares) and livestock assets (total livestock unit) were higher for households using dung cake and crop residue compared to other households using gas, while the value of owned nonagricultural land was higher for households using gas than households using fuelwood, dung cake, and crop residue for cooking.

Only about 1% of the households did not have a toilet, 5% of households had a pit latrine, and 94% had a latrine with a flush. About 98% of households with flush toilets use gas for cooking compared to 83% for those using fuelwood and 82% for those using dung cake and crop residue. About 91% of the households had a brick-walled house, and 38% had a cement and metal roof. Descriptive statistics show that households with brick walls and cement and metal roofs are more likely to use gas for cooking.

About 98% of the households were less than 30 minutes from a high school, and for all the surveyed households, the distance to a store was less than 30 minutes. The provincewide distribution of the sample indicates that 51% of the respondents were from Punjab, 8% from Khyber Pakhtunkhwa, 32% from Sindh, and 9% from Balochistan.

B. Econometric Findings

1. Results from the Ordered Probit Model Estimation

We estimated the ordered probit econometric model to study the factors that determine a household’s choice of cooking fuel. We organized and ordered the households into different categories based on the fuel used for cooking, with dung and crop residue at the base of the energy ladder followed by fuelwood and then gas at the top. Table 6 summarizes the marginal effects of the results obtained from the ordered probit model.

The results show that households with older heads are more likely to adopt gas and unlikely to use fuelwood, dung, and crop residue as sources of fuel for cooking. The elderly need more convenient sources of fuel as they do not have the strength to travel longer distances to collect fuelwood. Unlike other studies, the

Table 6. **Determinants of Choice of Energy Sources for Cooking: Ordered Probit Model (marginal effects)**

	Dung and Crop Residue	Fuelwood	Gas
Demographic			
Age of household head	−0.0006**	−0.0043***	0.0049***
	(0.0003)	(0.0016)	(0.0018)
Age squared (multiplied by 1,000)[a]	0.0043	0.0299*	−0.0342*
	(0.0026)	(0.0163)	(0.0188)
Gender of the head (female)[b,c]	−0.0020	−0.0146	0.0166
	(0.0022)	(0.0157)	(0.0178)
Household size	0.0010***	0.0068***	−0.0078***
	(0.0003)	(0.0019)	(0.0022)
Human capital and education			
Below primary[b,d]	−0.0023	−0.0170	0.0193
	(0.0024)	(0.0181)	(0.0204)
Primary completed[b,d]	−0.0070***	−0.0541***	0.0611***
	(0.0019)	(0.0104)	(0.0115)
Middle school completed[b,d]	−0.0097***	−0.0813***	0.0910***
	(0.0025)	(0.0119)	(0.0132)
Secondary school completed [b,d]	−0.0109***	−0.0891***	0.1000***
	(0.0026)	(0.0127)	(0.0138)
Senior secondary school completed[b,d]	−0.0089***	−0.0745***	0.0834***
	(0.0027)	(0.0166)	(0.0184)
University completed[b,d]	−0.0139***	−0.1240***	0.1380***
	(0.0035)	(0.0168)	(0.0183)
Wealth and assets			
Assets index	−0.0052***	−0.0363***	0.0416***
	(0.0010)	(0.0029)	(0.0027)
Agricultural land owned (hectares)	0.0001	0.0006	−0.0006
	(0.0001)	(0.0004)	(0.0005)
Value of nonagricultural land owned (million Pakistan rupees)	−0.0020***	−0.0136***	0.0156***
	(0.0007)	(0.0040)	(0.0045)
Livestock assets	0.0015***	0.0107***	−0.0123***
	(0.0005)	(0.0023)	(0.0026)
Access to facilities			
Distance to high school (within 30 minutes)[b,e]	−0.0174*	−0.0914**	0.1090**
	(0.0092)	(0.0393)	(0.0479)
Location: province			
Khyber Pakhtunkhwa[b,f]	−0.0129***	−0.1190**	0.1320***
	(0.0044)	(0.0469)	(0.0501)
Punjab[b,f]	−0.0219**	−0.1430***	0.1650***
	(0.0095)	(0.0547)	(0.0631)
Sindh[b,f]	−0.0236***	−0.1840***	0.2070***
	(0.0066)	(0.0492)	(0.0537)
Number of observations	13,947		
Wald chi-squared test (18)	825		
Prob > chi-squared	0.000		
Pseudo R-squared	0.149		
Log pseudolikelihood	−8,263		

Continued.

Table 6. *Continued.*

Notes: *** = 1% level of significance, ** = 5% level of significance, and * = 10% level of significance. Robust standard errors in parentheses.
[a]Coefficient multiplied by 1,000 to represent results within four digits after the decimal.
[b]Dummy variables
[c]Excluded category: male household head
[d]Excluded category: household head without any formal education
[e]Excluded category: households more than 30 minutes away from high schools
[f]Excluded category: Balochistan
Source: Authors' calculations.

current study does not show a significant influence of a female head in choosing clean energy. The number of members of a household is found to be positive and significantly associated with a household's use of dung and crop residue and fuelwood at the 1% level of significance, while it is negative and significant for a household's use of gas at the 1% level. Households with larger families are likely to have an abundant supply of labor to collect fuelwood and prepare dung cake, and the amount of energy needed for large households is quite high so it may be too expensive to purchase and use gas.

The probability of using gas increases with the level of education, while the likelihood of using dirty fuel decreases progressively as the level of education increases. This finding once again endorses the distinctive role of human capital in the household's decision to select clean fuel versus dirty fuel for cooking. The role of education in adopting clean energy emerges as one of the critical variables in this study and several previous studies (Rahut, Behera, and Ali 2016a and 2016b; Ekholm et al. 2010; Heltberg 2004; Hosier and Dowd 1987; Hou et al. 2017). The importance of education in clean energy use arises from the fact that the opportunity cost for educated people of collecting fuelwood and making dung cake is high. Moreover, education brings about awareness of the adverse health impacts of using dirty fuel.

The coefficient of the household wealth index is positive and significant (at the 1% level) for gas, while it is negative and significant (at the 1% level) for the use of dung, crop residue, and fuelwood. A positive link with gas and a negative relationship with dirty fuels signify that richer households are more likely to use cleaner fuels such as gas and are less likely to use solid fuels such as dung, crop residue, and fuelwood. Wealth and income of households determine the household capacity to pay for modern fuel, which is expensive, while fuelwood, crop residue, and dung could be collected by using surplus labor for free. The positive association of income and wealth on the adoption and use of clean energy is clearly pointed out by a number of previous studies (Bisu, Kuhe, and Iortyer 2016; Huang 2015; Joshi and Bohara 2017; Karimu 2015; Kwakwa, Wiafe, and Alhassan 2013; Makonese, Ifegbesan, and Rampedi 2017; Ouedraogo 2006; Pachauri and Jiang 2008; Pandey and Chaubal 2011; Rao and Reddy 2007; Reddy and Srinivas 2009; Rahut, Behera, and Ali 2016a). The agricultural land owned does not have an impact on the choice of cooking energy used, while the value of nonagricultural landed owned is positively associated with the use of gas and negatively related to the use of dung, crop residue, and fuelwood. Livestock assets are positively and significantly associated with dung, crop residue, and fuelwood, while negatively related to gas, which is obvious as those households with more livestock are likely to produce dung and use dung cake.

The coefficient of the dummy for the distance from home to a high school (a dummy value of 1 if a high school is within 30 minutes from the household; 0 otherwise) is positive and significant (at the 1% level) for the use of gas as cooking fuel, while it is negative and significant (at the 1% level) for the use of solid fuels such as dung, crop residue, and fuelwood. The distance to a high school (accessibility) has a divergent influence on a household's choice of clean and dirty fuels: households with better access are more likely to use clean fuels, while households with poor access to facilities are more likely to use dirty fuels. The closeness to the market and facilities means easy access and an adequate supply of clean energy, which is critical for the household to use clean fuels. This finding supports results from other studies such as those by Rahut et al. (2014); Rahut, Mottaleb, and Ali (2017); Karimu (2015); and Mensah, Marbuah, and Amoah (2016).

To control for spatial heterogeneity, we included a provincial dummy variable and found that, compared to urban households in the province of Balochistan, households in Khyber Pakhtunkhwa, Punjab, and Sindh are more likely to use gas for cooking and less likely to use dung, crop residue, and fuelwood.

2. Robustness Tests

Table 7 shows the results of the ordered probit model, which was reestimated by keeping other independent and dependent items the same and replacing a few key variables such as education and wealth.[1] Following recent literature which suggests that research on energy switching behaviors should go beyond income (van der Kroon, Brouwer, and van Beukering 2013), we have used different specifications of education in this section to explain the relationship between education and household energy choice.

In specification 1 of Table 7, the level of education of household heads was replaced by the maximum years of schooling of the adult members in the household. The coefficient of this variable is positive and significant (at the 1% level) for households using gas, while it is negative and significant (at the 1% level) for households using solid fuels (fuelwood, dung cake, and crop residue). In specification 2, the level of schooling of the head of the family was substituted

[1] A complete and detailed model is available upon request.

Table 7. **Factors Influencing Choice of Energy Sources for Cooking: Ordered Probit Model for Robustness Checks (marginal effects)**

	Dung and Crop Residue	Fuelwood	Gas
Specification 1			
Maximum education of adults	−0.0015***	−0.0106***	0.0121***
	(0.0004)	(0.0013)	(0.0015)
Specification 2			
Maximum education of adult males	−0.0005**	−0.0038***	0.0043***
	(0.0002)	(0.0012)	(0.0014)
Maximum education of adult females	−0.0015***	−0.0111***	0.0126***
	(0.0004)	(0.0010)	(0.0011)
Specification 3			
Mean education of adults	−0.0024***	−0.0181***	0.0206***
	(0.0006)	(0.0018)	(0.0021)
Specification 4			
Mean education of adult males	−0.0005**	−0.0040***	0.0045***
	(0.0002)	(0.0013)	(0.0015)
Mean education of adult females	−0.0019***	−0.0146***	0.0164***
	(0.0004)	(0.0012)	(0.0014)
Specification 5			
Years of schooling of household head	−0.0012***	−0.0085***	0.0098***
	(0.0003)	(0.0012)	(0.0014)
Specification 6			
Mean education of spouse	−0.0018***	−0.0140***	0.0158***
	(0.0004)	(0.0013)	(0.0015)
Specification 7			
Maximum education of elderly	−0.0007**	−0.0058***	0.0065***
	(0.0003)	(0.0022)	(0.0024)
Specification 8			
Mean education of elderly	−0.0007**	−0.0060***	0.0067***
	(0.0003)	(0.0023)	(0.0025)
Specification 9			
Education of oldest family member	−0.0012***	−0.0081***	0.0092***
	(0.0003)	(0.0010)	(0.0012)
Specification 10			
Years of schooling = 1[a,b]	0.0199	0.1020	−0.1220
	(0.0233)	(0.0875)	(0.1100)
Years of schooling = 2[a,b]	−0.0052	−0.0415	0.0467
	(0.0037)	(0.0324)	(0.0359)
Years of schooling = 3[a,b]	−0.0006	−0.0044	0.0050
	(0.0039)	(0.0278)	(0.0317)

Continued.

Table 7. *Continued.*

	Dung and Crop Residue	Fuelwood	Gas
Years of schooling = 4[a,b]	−0.0031	−0.0234	0.0265
	(0.0032)	(0.0252)	(0.0283)
Years of schooling = 5[a,b]	−0.0065***	−0.0516***	0.0581***
	(0.0018)	(0.0106)	(0.0117)
Years of schooling = 6[a,b]	−0.0088***	−0.0778***	0.0866***
	(0.0027)	(0.0227)	(0.0246)
Years of schooling = 7[a,b]	−0.0054*	−0.0428*	0.0481*
	(0.0029)	(0.0244)	(0.0270)
Years of schooling = 8[a,b]	−0.0097***	−0.0831***	0.0928***
	(0.0025)	(0.0115)	(0.0127)
Years of schooling = 9[a,b]	−0.0076***	−0.0646***	0.0721***
	(0.0029)	(0.0241)	(0.0265)
Years of schooling = 10[a,b]	−0.0107***	−0.0887***	0.0994***
	(0.0026)	(0.0127)	(0.0138)
Years of schooling = 11[a,b]	−0.0093***	−0.0791***	0.0884***
	(0.0028)	(0.0173)	(0.0191)
Years of schooling = 12[a,b]	−0.0002	−0.0011	0.0012
	(0.0058)	(0.0408)	(0.0465)
Years of schooling = 13[a,b]	−0.0137***	−0.1360***	0.1500***
	(0.0032)	(0.0171)	(0.0178)
Years of schooling = 14[a,b]	−0.0114***	−0.1130**	0.1240***
	(0.0035)	(0.0448)	(0.0472)
Years of schooling = 15[a,b]	−0.0110***	−0.0999***	0.111***
	(0.0033)	(0.0208)	(0.0231)
Years of schooling = 16[a,b]	−0.0156***	−0.2260***	0.2420***
	(0.0037)	(0.0223)	(0.0227)
Specification 11			
Cement and metal roof[a,c]	−0.0283***	−0.1890***	0.2170***
	(0.0052)	(0.0228)	(0.0237)
Specification 12			
No toilet[a,d]	0.0814***	0.2200***	−0.3020***
	(0.0142)	(0.0241)	(0.0310)
Pit toilet [a,d]	0.0667***	0.2050***	−0.2720***
	(0.0157)	(0.0211)	(0.0310)
Specification 13			
Brick-walled house[a,e]	−0.0666***	−0.2140***	0.2810***
	(0.0122)	(0.0224)	(0.0274)
Specification 14			
Number of elderly (>65 years)	0.0022*	0.0153*	−0.0175*
	(0.0011)	(0.0086)	(0.0097)
Number of children (<15 years)	0.0016***	0.0109***	−0.0125***
	(0.0004)	(0.0024)	(0.0027)
Adult members (15–65 years)	0.0001	0.0005	−0.0006
	(0.0004)	(0.0027)	(0.0030)

Continued.

Table 7. *Continued.*

	Dung and Crop Residue	Fuelwood	Gas
Specification 15			
Number of children (<15 years)	0.0016***	0.0109***	−0.0125***
	(0.0004)	(0.0024)	(0.0027)
Number of adult males (15–65 years)	0.00004	0.0003	−0.0003
	(0.0005)	(0.0033)	(0.0038)
Number of adult females (15–65 years)	0.0001	0.0009	−0.0010
	(0.0006)	(0.0043)	(0.0050)
Number of elderly (>65 years)	0.0022*	0.0153*	−0.0175*
	(0.0012)	(0.0087)	(0.0098)

Notes: ***1% level of significance, **5% level of significance, and *10% level of significance. Robust standard errors in parentheses. In Table 7, we reported only those variables that were replaced; the rest of the variables can be provided upon request.
[a]Dummy variables
[b]Excluded category: household head without any formal education
[c]Excluded category: households with nonmetal and cement roofs
[d]Excluded category: households with flush toilets
[e]Excluded category: households with mud, wood, and bamboo walls
Source: Authors' calculations.

by the maximum years of schooling of the adult female and the adult male member of the household separately. Both variables are positive and significant (at the 1% level) for households using gas, while it is negative and significant (at the 1% level) for those using solid fuels.

In specification 3, the level of education of the household heads was replaced by the average years of schooling of the adult member of the household. This variable's coefficient is positive and significant (at the 1% level) for households using gas, while it is negative and significant (at the 1% level) for those using dirty fuels. In specification 4, the level of education of the household heads was substituted by the average years of schooling of the adult female and male members of the family. Both variables are positive and significant (at the 1% level) for households using gas, while it was found to be negative and significant (at the 1% level) for households using dirty fuels.

In specification 5, the educational attainment of the head of the family was substituted by the head's number of years of schooling. This variable's coefficient is positive and significant (at the 1% level) for households using gas, while it was found to be negative and significant (at the 1% level) for those using solid fuels. In specification 6, the educational attainment of the head of the household was substituted by the years of schooling attained by the spouse of the head of the family. This variable's coefficient is positive and significant (at the 1% level) for households using gas, while it was found to be negative and significant (at the 1% level) for households using solid fuels.

In specification 7, the level of education of the household heads was replaced by the maximum years of schooling of the elderly household members. The coefficient of this variable is positive and significant (at the 1% level) for households using gas, while it was found to be negative and significant (at the 1% level) for those using solid fuels. In specification 8, the level of education of household heads was replaced by the mean years of schooling of the elderly household members, and its coefficient is positive and significant (at the 1% level) for households using gas and negative and significant (at the 1% level) for those using solid fuels. In specification 9, the level of education of household heads was replaced by the years of schooling of the oldest members of the household. The coefficient of this variable is positive and significant (at the 1% level) for households using gas, while it is negative and significant (at the 1% level) for households using solid fuels.

In specification 10, we converted every year of schooling into a dummy and reestimated the ordered probit model. To confirm the importance of education, the coefficient of the dummy for every year of schooling of the household heads after year 5 is positive and significant (at the 1% level) for households using gas, while it was found to be negative and significant at the 1% level for those using solid fuels.

Wealth of the family is a crucial factor that influences the family's decision to select fuel for domestic purposes. In specifications 11, 12, and 13, the model was reestimated separately by replacing the assets index with a dummy for roof materials (metal and cement roof equal to 1, otherwise 0); a dummy for the quality of the wall of the house (house with a brick wall equal to 1, otherwise 0); and a dummy for toilet types (no latrine equal to 1, pit latrine equal to 1, and flush toilet equal to 0). We found that wealthy households are more likely to choose gas for cooking and that poor households depend on solid fuels. These findings on the positive impact of wealth on the choice of clean fuel is consistent with the theory and also with the results obtained in Table 1. In specifications 14 and 15, we disaggregated household size into number of children, number of adult members (male and female), and number of elderly. We found that the number of children and elderly was positively associated with the use of gas and fuelwood and negatively associated with the use of dung and crop residue.

VI. Conclusion and Policy Implications

Using the latest nationally representative dataset, the 2014–2015 Pakistan Social and Living Standards Measurement Survey, this study investigates the factors contributing to a family's choice of cooking fuels. The narrative inquiry illustrates that, even today, a significant proportion of the population in urban areas of Pakistan rely on solid fuels for cooking, which is injurious to the environment and human health. It also shows that human capital, economic status of households, gender, and location influence the fuel used by households for cooking. More specifically, households with educated heads and wealthier households prefer to use clean energy sources such as gas for cooking, while poorer households tend to depend on dung, crop residue, and fuelwood.

Ordered probit models illustrate that financial and human capital are the key drivers of the household's cooking fuel choice in urban Pakistan. The different models with various measures of education (years of schooling of the head and spouse, level of education of the head, average years of schooling of adult males and females, and education of the adult male and female by age categories) and wealth (types of roofing, wall, and toilets) were estimated and the results were found to be extremely robust, signifying the importance of education and wealth on energy use behavior in urban Pakistan. Even the sensitivity analysis model with different sample sizes showed the consistency of the findings. Families with low levels of educational attainment are more likely to rely on solid fuels for cooking because they often do not have adequate knowledge about the adverse implications of using solid fuels. Moreover, their earnings are too low to be able to pay the cost of gas. Low-income families or families with low levels of financial and physical capital are reliant on traditional and solid, dirty fuels for cooking, while families with higher levels of human, physical, and financial capital are reliant on clean sources of fuel such as gas for cooking.

The results of the current study provide crucial inputs for household energy policies in Pakistan. Human capital is vital for enhancing knowledge about the health cost of using solid fuels and for improving family earnings by providing the capacity to diversify employment opportunities in lucrative sectors. Thus, regular campaigns to create awareness of the negative impacts of dirty energy on human health and the environment, better provision of education, and enhancing opportunities to increase family income are the key catalysts for encouraging the use of clean fuel by households. Hence, policies should aim at enhancing human capital by investing in education on the one hand and generating opportunities for livelihood diversification on the other.

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Appendix

T-tests of Adult Male and Female Education

	Male	Female	Difference
Maximum education of adult	10.0	6.7	3.3***
	(5.4)	(5.9)	(0.1)
Mean education of adult	7.7	5.3	2.4***
	(5.0)	(5.1)	(0.1)

Notes: Standard deviations in parentheses. ***1% level of significance.
Source: Authors' calculations from Pakistan Social and Living Standards Measurement Survey.