CEEW
THE COUNCIL

Are India's Urban Poor Using Clean Cooking Fuels?

Insights from Slums in Six States

Shaily Jha, Sasmita Patnaik, and Rithima Warrier

Issue Brief | March 2021

Between December 2019 to March 2020, CEEW surveyed the primary cook of households across urban slums from the six states of Bihar, Jharkhand, Uttar Pradesh, Rajasthan, Madhya Pradesh and Chhattisgarh.

Image: CEEW

CEEW
THE COUNCIL

Are India's Urban Poor Using Clean Cooking Fuels?

Insights from Slums in Six States

Shaily Jha, Sasmita Patnaik, and Rithima Warrier

CEEW Issue Brief
March 2021
ceew.in

Suggested citation: Jha, Shaily, Sasmita Patnaik, and Rithima Warrier. 2021. *Are India's Urban Poor Using Clean Cooking Fuels? Insights from Slums in Six States.* New Delhi: Council on Energy, Environment and Water.

Disclaimer: The views expressed in this issue brief are those of the authors and do not necessarily reflect the views and policies of Council on Energy, Environment and Water. The views/ analysis expressed in this study do not necessarily reflect the views of the MacArthur Foundation. The Foundation also does not guarantee the accuracy of any data included in this publication nor does it accept any responsibility for the consequences of its use.

Cover image: iStock.

Peer reviewers: Ashish Gupta, PhD student, University of Pennsylvania; Vinaya Padmanabhan, Consultant, Oxford Policy Management; and Abhishek Jain, Fellow and Director-Powering Livelihoods, CEEW.

Publication team: Alina Sen (CEEW), The Clean Copy, Twig Designs, and Friends Digital.

Organisation: The **Council on Energy, Environment and Water** (CEEW) is one of Asia's leading not-for-profit policy research institutions. The Council uses data, integrated analysis, and strategic outreach to explain – and change – the use, reuse, and misuse of resources. It prides itself on the independence of its high-quality research, develops partnerships with public and private institutions, and engages with wider public. In 2021, CEEW once again featured extensively across ten categories in the *2020 Global Go To Think Tank Index Report*. The Council has also been consistently ranked among the world's top climate change think tanks. Follow us on Twitter @CEEWIndia for the latest updates.

Council on Energy, Environment and Water
Sanskrit Bhawan, A-10 Qutab Institutional Area,
Aruna Asaf Ali Marg, New Delhi - 110067, India

About CEEW

The Council on Energy, Environment and Water (CEEW) is one of Asia's leading not-for-profit policy research institutions. **The Council uses data, integrated analysis, and strategic outreach to explain — and change — the use, reuse, and misuse of resources**. The Council addresses pressing global challenges through an integrated and internationally focused approach. It prides itself on the independence of its high-quality research, develops partnerships with public and private institutions, and engages with the wider public.

The Council's illustrious Board comprises Mr Jamshyd Godrej (Chairperson), Mr Tarun Das, Dr Anil Kakodkar, Mr S. Ramadorai, Mr Montek Singh Ahluwalia, Dr Naushad Forbes, Ambassador Nengcha Lhouvum Mukhopadhaya, and Dr Janmejaya Sinha. The 100 plus executive team is led by Dr Arunabha Ghosh. CEEW is certified as a **Great Place To Work®**.

In 2021, CEEW once again featured extensively across ten categories in the *2020 Global Go To Think Tank Index Report*, including being ranked as **South Asia's top think tank (15th globally) in our category for the eighth year in a row**. CEEW has also been ranked as South Asia's top energy and resource policy think tank for the third year running. It has consistently featured among the world's best managed and independent think tanks, and twice among the world's 20 best climate think tanks.

In ten years of operations, The Council has engaged in 278 research projects, published 212 peer-reviewed books, policy reports and papers, created 100+ new databases or improved access to data, advised governments around the world nearly 700 times, promoted bilateral and multilateral initiatives on 80+ occasions, and organised 350+ seminars and conferences. In July 2019, Minister Dharmendra Pradhan and Dr Fatih Birol (IEA) launched the CEEW Centre for Energy Finance. In August 2020, Powering Livelihoods — a CEEW and Villgro initiative for rural start-ups — was launched by Minister Mr Piyush Goyal, Dr Rajiv Kumar (NITI Aayog), and H.E. Ms Damilola Ogunbiyi (SEforAll).

The Council's major contributions include: The 584-page *National Water Resources Framework Study* for India's 12th Five Year Plan; the first independent evaluation of the *National Solar Mission*; India's first report on global governance, submitted to the National Security Adviser; irrigation reform for Bihar; the birth of the Clean Energy Access Network; work for the PMO on accelerated targets for renewables, power sector reforms, environmental clearances, Swachh Bharat; pathbreaking work for the Paris Agreement, the HFC deal, the aviation emissions agreement, and international climate technology cooperation; the concept and strategy for the International Solar Alliance (ISA); the Common Risk Mitigation Mechanism (CRMM); critical minerals for *Make in India*; modelling uncertainties across 200+ scenarios for India's low-carbon pathways; India's largest multidimensional energy access survey (ACCESS); climate geoengineering governance; circular economy of water and waste; and the flagship event, Energy Horizons. It recently published *Jobs, Growth and Sustainability: A New Social Contract for India's Recovery*.

The Council's current initiatives include: A go-to-market programme for decentralised renewable energy-powered livelihood appliances; examining country-wide residential energy consumption patterns; raising consumer engagement on power issues; piloting business models for solar rooftop adoption; developing a renewable energy project performance dashboard; green hydrogen for industry decarbonisation; state-level modelling for energy and climate policy; reallocating water for faster economic growth; creating a democratic demand for clean air; raising consumer awareness on sustainable cooling; and supporting India's electric vehicle and battery ambitions. It also analyses the energy transition in emerging economies, including Indonesia, South Africa, Sri Lanka and Viet Nam.

The Council has a footprint in 21 Indian states, working extensively with state governments and grassroots NGOs. It is supporting power sector reforms in Uttar Pradesh and Tamil Nadu, scaling up solar-powered irrigation in Chhattisgarh, supporting climate action plans in Gujarat and Madhya Pradesh, evaluating community-based natural farming in Andhra Pradesh, examining crop residue burning in Punjab, and promoting solar rooftops in Delhi and Bihar.

Acknowledgments

The authors would like to thank the partners for this survey, Initiative for Sustainable Energy Policy (ISEP), at the Johns Hopkins School of Advanced International Studies (SAIS). We would like to extend our gratitude to Prof. Johannes Urpelainen (Johns Hopkins SAIS), Carlos F. Gould (Columbia University), and Alice Tianbo Zhang (Washington and Lee University) for leading the design of the survey instrument and giving us regular inputs and feedback in various stages of survey planning and implementation. We would also like to thank our colleagues at CEEW, Kurinji Selvaraj and Tanushree Ganguly, for providing the district level air quality data for the analysis.

The authors would like to acknowledge the valuable support of Market Xcel Private Ltd, the survey agency, and its survey team for administering the survey and collecting data. Our deepest gratitude goes to them. Special thanks to Prasenjit Saha and Pooja Sirpaul (Market Xcel Private Ltd) who were instrumental in implementing the survey. We would also like to thank the MacArthur Foundation for financially supporting the study.

We want to thank our reviewers—Ashish Gupta, University of Pennsylvania; Vinaya Padmanabhan, Oxford Policy Management; and Abhishek Jain, CEEW—for providing critical feedback and comments that went a long way in refining this report.

The authors

Shaily Jha
shaily.jha@ceew.in

Shaily is a Research Analyst in the Energy Access team at The Council. She works on access to clean cooking energy and livelihoods with a focus on gender and social inclusion. Shaily holds a postgraduate degree in Disaster Management from the Tata Institute of Social Sciences (TISS), Mumbai, and an undergraduate degree in Geography from Miranda House, University of Delhi.

"Even though the use of LPG as an exclusive cooking fuel is more prominent in urban households than their rural counterparts, a significant share of the urban population living in slums is struggling to incorporate the cost of using LPG into the household budget. The pollution burden for these households is doubled, as they are exposed to the high ambient particulate matter pollution of cities along with the household air pollution from the use of polluting cooking fuels."

Sasmita Patnaik
sasmitaa.patnaik@gmail.com

Sasmita is a former Programme Lead of the Energy Access team at The Council. She led the work on access to clean cooking and livelihoods, with a focus on gender and social inclusion. She holds an MSc in Development Studies from the School of Oriental and African Studies (SOAS) and a postgraduate diploma in Rural Management from Xavier Institute of Management, Bhubaneswar (XIMB).

"Policies on clean cooking energy access have not necessarily targeted energy poverty in urban slums. In a rapidly urbanising country facing a crisis of air pollution and now recovering from the economic impacts of COVID-19, it is time that we target policies to alleviate energy poverty in urban slums, particularly in Tier 2 and Tier 3 cities. Women and children are the worst affected by the use of polluting fuels, reinforcing the need to focus on women's ability to use clean cooking energy solutions even after schemes like Pradhan Mantri Ujjwala Yojana."

Rithima Warrier
rithima2warrier@gmail.com

Rithima worked as Research Consultant at The Council where she analysed primary data on energy access for rural households and urban slums of India. Rithima holds an MTech in Bioscience and Bioengineering with a specialisation in Energy from the Indian Institute of Technology, Guwahati (IITG), and a BE in Chemical Engineering, from M.S. Ramaiah Institute of Technology (MSRIT), Bangalore.

"During data analysis, we realised that even within polluting fuel-using slum households, the reasons for not transitioning towards cleaner fuel varied between the households that stacked LPG with polluting fuels and the ones that only used polluting fuels. Moreover, the economic impact of COVID-19 is expected to further hinder the transition to cleaner fuels in these slums."

Urban slums suffer from the double burden of pollution as they are exposed to the high ambient particulate matter pollution of cities along with the household air pollution (HAP) from the using unclean cooking fuels.

Image: iStock

Contents

Tables

Figures

Acronyms

BPL	below poverty line
CAAQMS	continuous ambient air quality monitoring stations
COPD	chronic obstructive pulmonary disease
COVID	coronavirus disease
DALY	disability-adjusted life year
DBTL	*Direct Benefit Transfer scheme for LPG*
HAP	household air pollution
IRES	*India Residential Energy Survey*
LPG	liquified petroleum gas
NSSO	National Sample Survey Office
OBC	Other Backward Castes
OMCs	oil and marketing companies
PMUY	*Pradhan Mantri Ujjwala Yojana*
SC	Scheduled Caste
SDI	socio-demographic index
ST	Scheduled Tribes

To reduce the health impacts from household air pollution, slum households that are stacking polluting fuels will need to transition using clean cooking fuels exclusively.

Image: iStock

Executive summary

With increased urbanisation, India is experiencing acute air pollution in its urban centres. Slum dwellers are doubly affected, both by the higher concentration of particulate matter in urban areas as well as indoor air pollution from the use of unclean cooking fuels. With more than 13.7 million people living in slums in country (Census 2011), there is a strong impetus to understand the use of clean cooking fuels in such households. Existing literature on energy access and use in slums across developing countries assume that energy infrastructure is available in these settlements as they are situated in urban environments (Butera et al. 2016). Household air pollution (HAP) has an estimated average contribution of 30–50 per cent to ambient air quality across India's urban and rural areas (Balakrishnan et al. 2019). Addressing biomass burning for cooking, water heating, and space heating during the winters has the potential to help reach the national ambient air quality standards (Chowdhury et al. 2019).

However, our analysis shows that a large share of these households do not have access to clean fuels due to lack of afforability or patchy supply. In this brief, we discuss access to clean cooking energy in urban slums across six states (Bihar, Uttar Pradesh, Rajasthan, Madhya Pradesh, Jharkhand, and Chhattisgarh). These states have a low socio-demographic index and a high disease burden due to air pollution (Balakrishnan et al. 2019). The findings of this brief are based on a primary survey conducted in rural areas and urban slums in these states – *Cooking Energy Access Survey 2020*[1]. The analysis focuses on the fuel use patterns of households, the extent of use of LPG and solid fuels, fuel stacking behaviour, and the primary cook's perception of various cooking fuels and their health impacts.

Use of LPG as primary fuel

82% (Cooking Energy Access Survey 2020)
47% (Census 2011)

Polluting fuel as primary fuel

16% (Cooking Energy Access Survey 2020)
52% (Census 2011)

Slum households vary widely in their use of clean cooking fuels. Therefore, to understand their cooking energy use patterns better, we categorised these households into three groups:

Using clean fuels exclusively,

Stacking clean fuels* with polluting fuels, and

Using only polluting fuels.

*In this brief, the use of clean cooking fuels is considered synonymous to use of LPG.

1. This has been referred as 'our survey' thereafter.

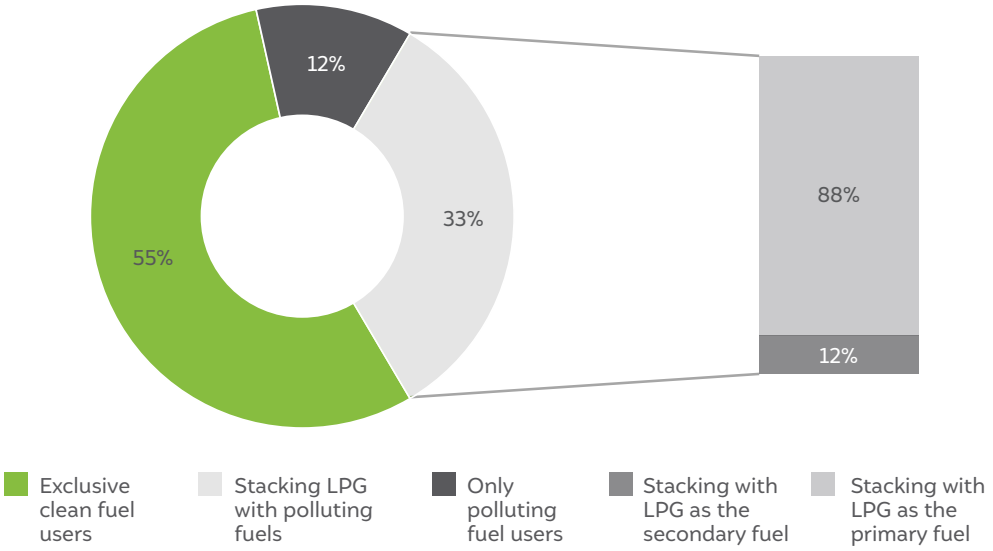


Figure ES1
To reduce the health impacts from household air pollution (HAP), households that are stacking with polluting fuels will need to transition to exclusive use of clean cooking fuels

Source: Authors' analysis

1. Households using LPG as their only fuel

While most urban slum households have an LPG connection, exclusive use of LPG is limited to just over half of the total households. The household's economic status (measured through asset ownership) and their access to doorstep delivery of LPG refills are two critical factors that determine their ability to use LPG exclusively. We found that households with higher asset ownership have significantly higher odds of using LPG as an exclusive fuel.

63%
LPG-using households receive doorstep delivery of cylinders

77%
households receiving doorstep delivery of LPG cylinders are exclusive users of the fuel

2. Households stacking LPG with polluting fuels

Although schemes like *Pradhan Mantri Ujjwala Yojana* (PMUY) have helped increase LPG adoption, this has not resulted in the complete replacement of biomass-based fuels. Despite 86 per cent of households having an LPG connection, the data shows that over a third of slum households are stacking with polluting fuels (including firewood, dung cakes, agriculture residue, charcoal, and kerosene). Most of these households use polluting fuels daily or at least weekly, which increases their exposure to household air pollution.

Among the households stacking LPG with polluting fuels, the reasons for stacking vary: affordability, free-of-cost availability of biomass, seasonality, and taste preferences. Across asset quintiles, we find that stacking is highest among the middle categories (second and third quintile), though most households in these categories have adopted LPG. Still, the affordability of the fuel remains a significant concern. One-fourth of households who are stacking polluting fuels have a median annual refill rate of eight cylinders and above (same as exclusive LPG users), despite having a similar household size as those using LPG exclusively. Most of such households fall in the wealthiest asset quintiles and use a *chulha* (mud stove) for cooking chapatis or vegetables, suggesting that they are not necessarily using unclean fuels due to the unaffordability of LPG, but due to other factors like taste.

Despite increased LPG adoption, stacking is prevalent in more than one-third of the slum households

21%
households stacking fuels have more than one LPG connections

25%
households stacking fuels have two-cylinder connections

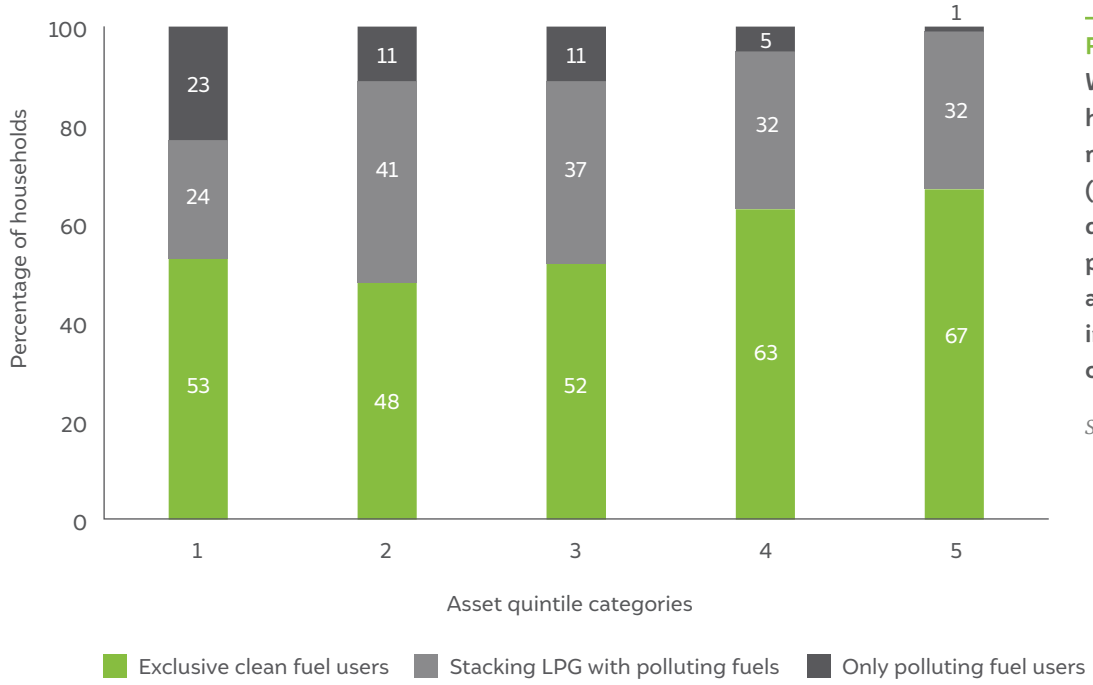


Figure ES2
While stacking is highest among the middle categories (second and third quintile), it is prevalent across all asset quintiles, including the highest one

Source: Authors' analysis

2.1 Non-cooking uses of polluting fuels

Despite using LPG as the primary fuel for their cooking needs, households that stack fuels use polluting fuels for non-cooking purposes like heating water for bathing (29 per cent) and space heating (10 per cent).

2.2 Seasonal variations in fuel use

Most households (88 per cent) use LPG as their primary fuel in the rainy season, while in winters, less than 45 per cent of households do so. The increased use of polluting fuels in winter could be because during these months, the polluting fuel requirement for non-cooking tasks within the household like water heating for bathing and space heating increases – which leads to the increased use of polluting fuels for cooking as well. Unfortunately, the increased use of polluting fuels in winters exposes households to the double burden of high ambient and household air pollution due to unfavourable atmospheric conditions.

3. Households using only polluting fuels

Despite large-scale government initiatives like *PMUY*, 12 per cent of urban slum households do not use LPG and rely on polluting fuels. While most of these households are aware of *PMUY*, the high upfront LPG connection cost, along with the high recurring expenditure on refills, deter them from procuring an LPG connection.

Way forward

While we see a progressive change in households' energy-use patterns as we move from rural to urban, issues like affordability, availability, preference, seasonality, and the end-uses of the fuel remain essential factors that determine household fuel choice. Understanding user categories and fuel use patterns is crucial in enabling access to and sustained use of clean cooking fuels. Also, it is vital to recognise the implications of cooking being a gendered activity. However, women's participation in intrahousehold decision-making regarding LPG use is limited.

50%
households' female members decide whether or when to purchase LPG refills

30%
households' female members place the order for LPG refills

Despite being in urban areas, 37 per cent of slum households do not receive home delivery of cylinders – availability is an essential factor that determines the household's likelihood of using LPG exclusively. **To increase LPG use, oil and marketing companies (OMCs) and distributors need to improve home delivery of LPG refills in slum areas**.

Emissions from household sources contribute hugely to the surrounding air quality (Harish et al. 2019), which is already poor in congested slum areas. Majority of households cook inside the main house without a chimney indicating high exposure to pollution from the use of unclean fuels for cooking.

75%
households' using polluting fuels cook inside the main house

67%
households' using polluting fuels do not have a chimney for ventilation

Integrate the issue of lack of access to clean cooking energy with urban poverty

This study reiterates the need to look at poverty in urban areas in the context of energy access. The vulnerability of urban slum dwellers needs to be accounted for while designing and implementing policies, including social protection schemes. Given the health and economic impacts of pollution, access to clean cooking energy schemes must be integrated with the social assistance programmes of other ministries (e.g., health, education, and nutrition assistance) to better target support for slum households. Government programmes such as the *National Urban Livelihoods Mission* and social service allocations for housing should use existing targeting approaches to include access to clean cooking energy within their ambit of services for the poor.

There is a need for targeted effort to include the poor households in urban slums left out in the first phase of *Ujjwala*

The economic impact from COVID-19 will push households into energy poverty, leading to the increased use of free-of-cost biomass – consequently increasing the risk of exposure to emissions from fuel burning. While the government has announced that it will provide up to three free refills under the *PM-Garib Kalyan Yojana* scheme to all *PMUY* households, **less than a quarter of households in urban slums have *Ujjwala* connections** – effectively making them ineligible for relief support. **There is a need to expand the reach of PMUY to cover all slum households.**

Bring renewed emphasis on clean cooking during COVID-19

Increased poverty would mean increased use of polluting fuels – there is a need for a renewed emphasis on clean cooking energy access during the COVID-19 pandemic as increased use of polluting fuels has health implications (lower respiratory infections and coronary chronic obstructive disease (COPD)) that increase the risk of COVID-19 infections being more severe.

Addressing biomass burning for cooking, water heating, and space heating during the winters has the potential to help reach the national ambient air quality standards.

Image: iStock

1. Introduction: state of India's urban slums

The *Census of India* (2011) estimates that India has about 13.7 million slum dwellers across the country. However, statistics on slum populations vary significantly based on how a slum is defined (Nolan 2015). Therefore, not only is there a lack of data about how many people live in slums and informal settlements, but there is also limited information about living conditions in slums (Rains, Krishna, and Wibbels 2018). Rapid urbanisation in India has led to population spikes in urban centres. Low-income households in urban areas are trapped in informal and sometimes 'illegal' settlements with poor living conditions, where access to essential services and infrastructure tends to be limited or badly deteriorated (Butera et al. 2016). While slum dwellers are not a homogeneous population, slum areas have high concentrations of poverty and social and economic deprivation and poor shelter and environmental conditions (UN-Habitat 2003).

BOX 1 Slums in India

The *Census of India* (2011) defines slums as "residential areas where dwellings are unfit for human habitation by reasons of dilapidation, overcrowding, faulty arrangements and design of such buildings, narrowness or faulty arrangement of street, lack of ventilation, light, or sanitation facilities or any combination of these factors which are detrimental to the safety and health." The slums in India are officially categorised into three categories: identified, recognised, and notified[1] (Chandramouli 2010). About 59 per cent of slum households in India are non-notified and are not legally recognised by the government (Nolan, Bloom, and Subbaraman 2018).

The existing literature on energy access and use in slums across developing countries suggests that while energy infrastructure (electric grid, LPG distribution system) is available in these settlements (by being urban), households cannot afford it and/or the service is unreliable (frequent outages and low voltage for electricity; uncertain availability of gas cylinders) (Butera et al. 2016). This leads to households relying on illegal connections for electricity and using energy sources that are on the lower end of the energy ladder (such as kerosene, charcoal, wood, and other biomass residues) for cooking (Butera et al. 2016).

1. Areas notified as slums by the concerned municipalities, corporations, local bodies or development authorities were termed notified slums. All areas recognised as 'Slum' by State, UT Administration or Local Government, Housing and Slum Boards, which may have not been formally notified as slum under any act. While a compact area of at least 300 population or about 60-70 households of poorly built congested tenements, in the unhygienic environment is termed as identified slums. (National Sample Survey Office 2012).

In India, population growth and rapid urbanisation have resulted in the deepening of urban poverty and the increased growth of urban slums (GNESD 2008; Yenneti, Wei, and Chen 2017). As per the Census 2011, most slum dwellers are casual labourers engaged in works other than public works (i.e., informal sectors) as opposed to salaried employees in non-slum urban areas (National Buildings Organisation 2013). As per the National Sample Survey Office (NSSO 2011–2012), the average daily wage of casual labourers is as low as INR 170 in urban areas (Ministry of Housing and Urban Affairs 2019). Such households may be able to purchase cleaner and more efficient fuels whenever they can, but are likely to fall back on less efficient ones when faced by budgetary constraints. Studies suggest that despite the LPG subsidies provided by the government, significant sections of the urban poor population are still struggling to incorporate the cost of LPG into their household budgets (R. Singh et al. 2015). Use of multiple fuels also provides security from price variations and unreliable service associated with a single fuel or technology (Shahadat, Lipu, and Bhuiyan 2014).

Slum-dwellers suffer from the double burden of pollution as they are exposed to high ambient particulate matter in cities along with the HAP from using unclean cooking fuels

As per the Census 2011, only half of the urban slum households across the country use LPG as their cooking fuel; the remaining rely on solid fuels and kerosene. Since 2013, the LPG programme in India has undergone many modifications to improve delivery and targeting, access to connections, and the availability of LPG (CEEW 2020). *Pradhan Mantri Ujjwala Yojana (PMUY)*, which focuses on tackling the high upfront cost of LPG by providing LPG connections to below poverty line (BPL) households with credit-linked subsidy support, has played an instrumental role in increasing the penetration of LPG across the country. As of November 2019, about 96.5 per cent of households in India have an LPG connection (PPAC 2019). Small towns and cities which have been experiencing a comparatively slow rate of urban growth but the high percentage of slum population mall towns and cities which have been experiencing a relatively slow rate of urban growth but a high percentage of slum population.

However, the dramatic increase in LPG coverage has led to increased fuel stacking (Cheng and Urpelainen 2014). The reliance on fuel stacking has significant implications as the health benefits of using clean fuels are reduced, or perhaps even nullified, in households that continue to use biomass (Cheng and Urpelainen 2014). Urban slums suffer from a double burden of pollution as they are exposed to high ambient particulate matter pollution in cities along with the household air pollution (HAP) from using unclean cooking fuels (WHO 2014). The *Global Burden of Disease* study notes that even with the substantial increase in the provision of clean cooking fuels in India, more than half of India's population is exposed to HAP from solid cooking fuels as of 2017 (Balakrishnan et al. 2019). In the current context, this is concerning since exposure to air pollution has been linked to developing lower respiratory infections and chronic obstructive pulmonary disease (Balakrishnan et al. 2019), which are among the major risk factors for COVID-19 (Lippi and Henry 2020; Wang et al. 2020).

1.1 Motivation and methodology

While there have been various studies on energy access in rural areas, there is minimal data on energy use and patterns in urban slum households. Most studies on urban slums and energy access focus on specific slums in large metropolitan areas such as Delhi and Bangalore (Saksena et al. 2003; Dhingra et al. 2008; Roy et al. 2018). Living conditions and access to resources vary across slums in smaller towns and cities compared to those in Tier I

cities; these towns have been experiencing a comparatively slow rate of urban growth but are home to large slum populations (Rahaman and Das 2017). Further, existing sources on access to clean cooking energy among slum households are limited to primary fuel use and lack detailed information about fuel use and stacking patterns.

In India, states with the lowest socio-demographic index (SDI)[2] also account for the highest level of disease burden due to air pollution (Balakrishnan et al. 2019). The low SDI states in north India had some of the highest levels of ambient particulate matter and household air pollution – especially Bihar, Uttar Pradesh, Rajasthan, and Jharkhand. The disability-adjusted life year (DALY) rate attributable to HAP was highest in the low SDI states of Chhattisgarh, Rajasthan, and Madhya Pradesh (Balakrishnan et al. 2019).

The findings of this brief are based on a primary survey conducted across rural areas and urban slums in six energy access deprived states in India – Bihar, Jharkhand, Uttar Pradesh, Rajasthan, Madhya Pradesh, and Chhattisgarh.[3] *The Cooking Energy Access Survey 2020*[4] focused on household's clean cooking energy access, and its barriers and drivers, in rural areas and urban slums. Based on the list of urban slums across districts in Census 2011, the survey covered 656 households across 83 urban slums (notified and non-notified)[5] spread across 58 districts. The survey was conducted with the primary cook of the household.[6]

State	Districts sampled	Urban slums sampled	Households surveyed
Uttar Pradesh	16	31	249
Bihar	14	15	124
Madhya Pradesh	10	16	128
Rajasthan	10	12	94
Jharkhand	4	5	40
Chhattisgarh	4	4	32
	58	**83**	**667**

Table 1
Sample allocation across urban slums

Source: Authors' compilation

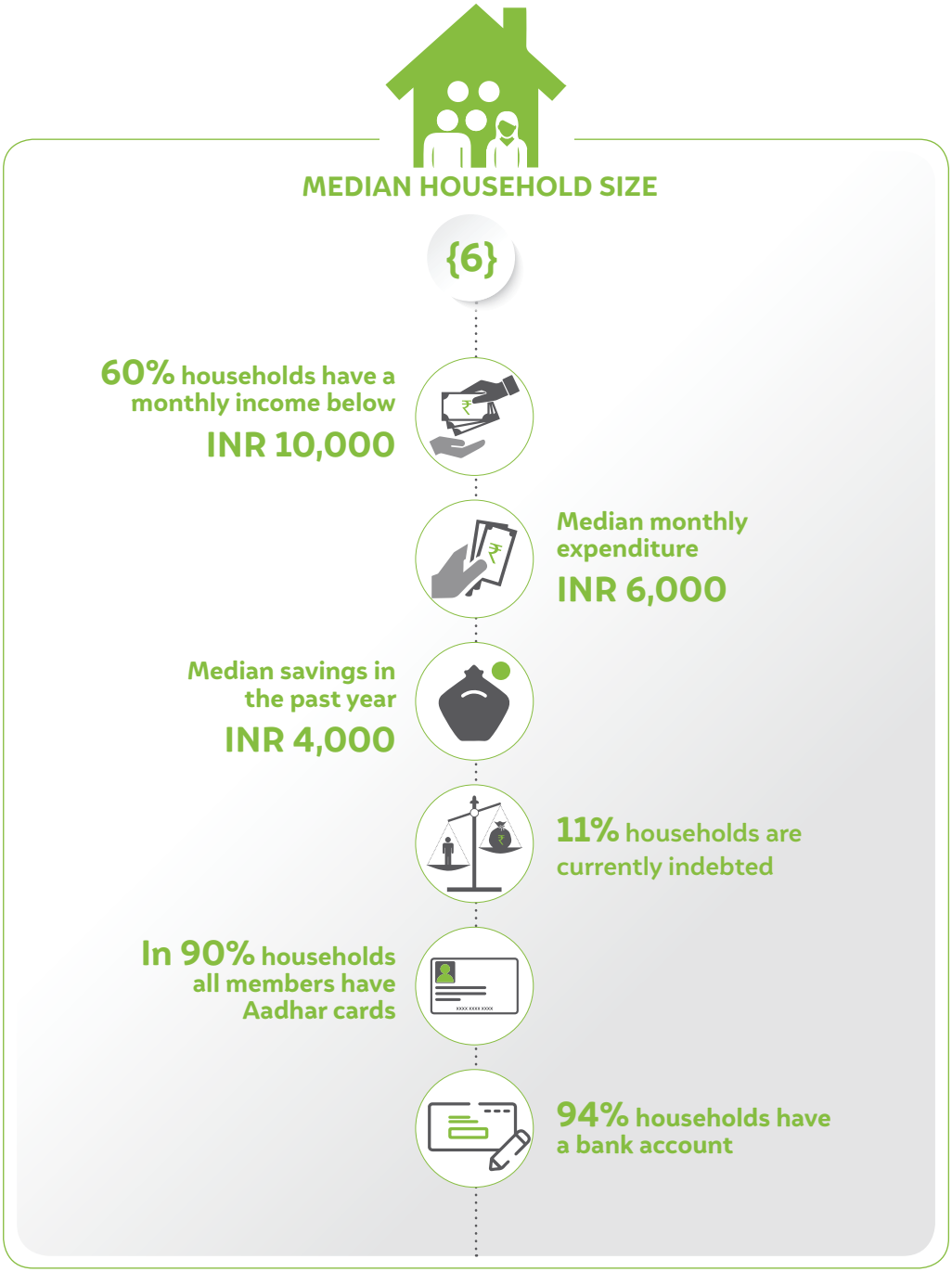
Note: The number of slums sampled within each state varied because the slums were picked from the same districts that were sampled under the India Residential Energy Survey (2020) across the six states. This was done to ensure logistical ease in conducting both the surveys and to share the resources of the national-level survey. The list of urban slums as per the Census 2011 in the districts sampled under IRES 2020 constitutes the urban sampling frame.[7]

In this brief, we focus on understanding access to clean cooking energy, specifically across urban slum households. The analysis focuses on the fuel use patterns of households, the extent of use of LPG and solid fuels, fuel stacking behaviour, and the primary cook's perception of various cooking fuels and their impact on health. The results discussed below are representative of the urban slum population in six states. We have refrained from state-level analysis because of the smaller sample size for urban slums in some states like Jharkhand and Chhattisgarh.

2. A summary measure that identifies where countries or other geographic areas fall on the spectrum of development. Expressed on a scale of 0 to 1, SDI is a composite average of the country's rankings in terms of per capita income, average educational attainment, and fertility rates.
3. These states account for six out of eight of the lowest socio-demographic index (SDI) states and exhibit the highest health impacts of household air pollution (HAP). These states also have the highest percentage of households covered under the flagship clean cooking energy programme in India – PMUY.
4. Referred to as 'our survey' thereafter.
5. In our sample, about 82 per cent of households are from notified slums.
6. About 98 per cent of the respondents were female members of the household.
7. For further details on the survey sample and methodology, refer to the technical document for the survey.

1.2 Socio-economic characteristics of the urban slums of the six states

Non-farm casual labour is the primary source of income for more than 42 per cent of the households; such households reported a median monthly expenditure of about INR 5,000. In only 20 per cent of the households, the primary cook is involved in income-generating activities, primarily engaged in casual non-farm labour or are self-employed.



Source: Authors' analysis

The primary source of income	% of urban slum households
Non-farm/daily wage casual labour	43
Private or government salaried job	22
Shop or own business or self-employed*	18
Farm labour	8
Agriculture on own or leased land	7
Others (pension, remittances, cattle rearing, none)	2

Table 2
Less than one-third of urban slum households reported income from salaried jobs

Source: Authors' analysis

**Under self-employment, some of the households' report occupations like carpentry, tailoring, driver and priest.*

Scheduled Castes (SC) (30 per cent) and Other Backward Castes (OBC) (45 per cent) form the majority of the urban slum population. While Scheduled Tribes (ST) constitute less than 10 per cent of the overall population, a majority of them are in Madhya Pradesh and Rajasthan. Less than 20 per cent of the urban slum population are from the General castes. States like Bihar, Jharkhand, and Rajasthan have the least proportion of General castes living in slum areas.

Within urban slum households, OBC and General households are relatively better off economically, as shown in Table 3. Occupational patterns also vary based on caste. A higher proportion of OBCs and General households rely on running a business, self-employment, or salaried jobs for their primary source of income as compared to SC and ST households. The latter are primarily engaged in farm and non-farm labour. The socio-economic marginality of SCs and STs even within slums is a consequence of these communities being most deprived in terms of access to resources and education, income, housing, etc. (Chandrasekhar and Mitra 2018). We see a similar trend in our sample in education and income levels. Slums often remain the permanent habitation of marginalised castes, as opposed to serving as an entry point for persons from higher castes who get absorbed into relatively better jobs and eventually move out of the slums (Chandrasekhar and Mitra 2018).

Caste	Sample size	Mean of asset index*	(Min. – Max.)	% of BPL cardholders
Scheduled Castes	233	0.42	(0–0.84)	45
Scheduled Tribes	51	0.39	(0.08–0.77)	60
Other Backward Classes	281	0.46	(0.03–1)	49
General	92	0.46	(0.08–0.9)	36

Table 3
Scheduled Castes and Scheduled Tribes have the lowest economic status

Source: Authors' analysis

**We utilise an economic status or asset index as a measure of a household's relative wealth and economic status, based on the Filmer and Pritchett (2001) approach. The list of variables included in the economic status index can be found in Annexure I. The index takes values between 0 and 10, where a higher value denotes a higher level of asset ownership.*

Exclusive use of LPG is limited to just over half of the total slum households. The household's economic status and its access to doorstep delivery of LPG refills are two critical factors that determine their ability to use LPG exclusively.

Image: iStock

2. Cooking fuel adoption and use in urban slum households

The fuel use patterns in urban slum households across the six states show a significant improvement in LPG use over the past decade when compared with the data from Census 2011. The share of households using polluting fuels (including firewood, dung cake, agriculture residue, and kerosene) as their primary fuel has decreased significantly, but we find that stacking is a common practice even among households using LPG as a primary fuel. Unless they use clean fuels exclusively, such slum households will still be exposed to the health risks associated with HAP.

Across the six states, the primary fuel used for cooking by slum households:

Use of LPG as primary fuel

82% (Cooking Energy Access Survey 2020)
47% (Census 2011)

Polluting fuel as primary fuel

16% (Cooking Energy Access Survey 2020)
52% (Census 2011)

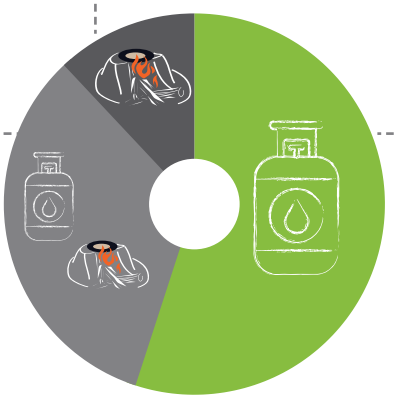
For the analysis in this brief, we have categorised the households into three based on their fuel choices and position on the energy ladder: those that exclusively use clean cooking fuels (LPG and electricity), stack LPG with polluting fuels, and use only polluting fuels. The level of exposure to emissions from cooking increases from the first (least harmful) to the third category (most harmful).

Fuel-use categories

12%

Households using only polluting fuels

These households only use firewood, charcoal, dung, agricultural residue, kerosene, or a stack of these fuels.



33%

Households stacking LPG with polluting fuels

Most of these households reported using LPG as their primary fuel and polluting fuels as their secondary fuel. About four per cent of slum households reported using polluting fuels as their primary fuel and LPG as their secondary fuel.

55%

Households using clean fuel exclusively*

While the majority of these households use LPG, two per cent of the households reported using electricity for cooking purposes.

** In this brief, the use of clean cooking fuels is considered synonymous to use of LPG since other clean fuels comprise a negligible share of use.*

Source: Authors' analysis

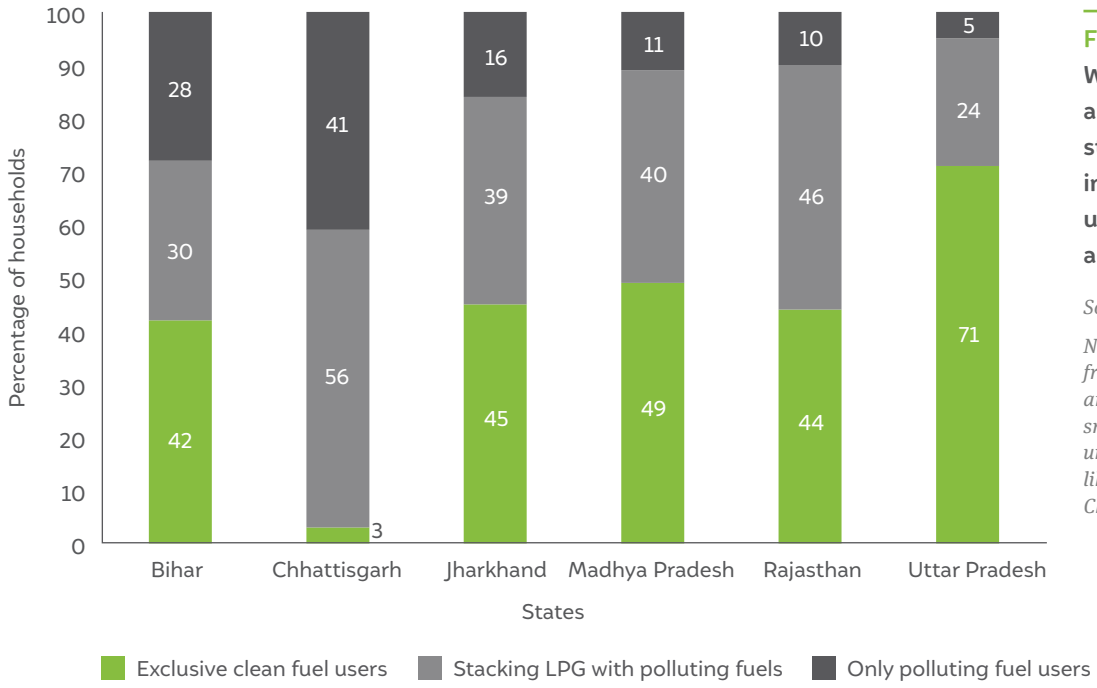


Figure 1

Within slums, there are considerable state-level variations in households' fuel usage patterns across states

Source: Authors' analysis

Note: We have refrained from state-level analysis because of the smaller sample size for urban slums in states like Jharkhand and Chhattisgarh.

In the following sections, we explore factors such as socio-economic characteristics, affordability and availability of fuel, intra-household gender dynamics, and fuel perceptions, which influence the ability and likelihood of a household to use different fuels.

2.1 Households using LPG as their only fuel

In this section, we focus on understanding the household characteristics and fuel use patterns of those using LPG exclusively for cooking. Most urban slum households with an LPG connection report using LPG as their primary fuel. While 55 per cent of the slum households (63 per cent of LPG-using households) use LPG exclusively, others stack LPG with polluting fuels. Uttar Pradesh has the highest proportion (70 per cent) of slum households who are exclusive users of clean cooking fuels among the six states.

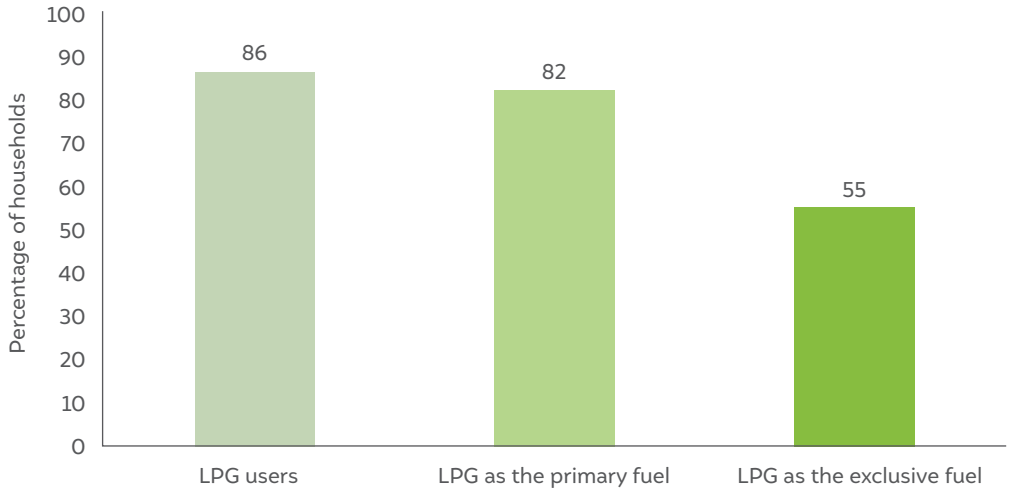


Figure 2

While the majority of LPG-using households use the fuel primarily, only half of them use it exclusively

Source: Authors' analysis

Over a fifth of households using LPG exclusively are *PMUY* households, which suggests that these households have been able to transition to clean cooking fuels in less than four years. *PMUY* households using LPG exclusively are of a relatively higher economic status than households that stack polluting fuels. Unlike in rural areas, the age of an LPG connection does not have a direct correlation with per capita LPG consumption in urban slum households, suggesting that even households with recent LPG connections in urban slums are likely to use LPG exclusively. Households in urban areas have been known to experience a direct transition to exclusive use of clean fuels from using traditional fuels (Kuo and Azam 2019). This could be due to the time-saving that comes with the adoption of clean cooking fuels like LPG – where urban households are more willing or need to spend more on convenience than rural households.

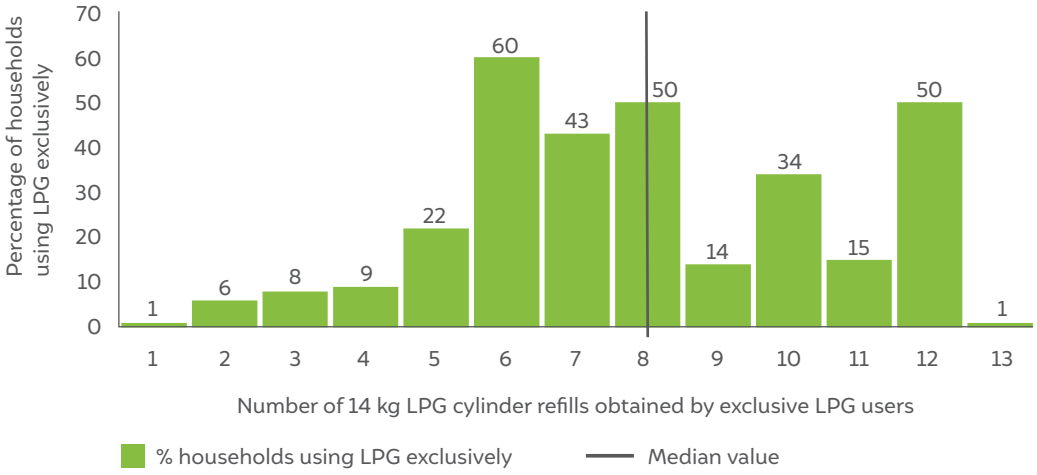


Figure 3
Most households using LPG exclusively acquire six to eight cylinders per year

Source: Authors' analysis

2.1.1 The economic status of the household determines exclusive LPG use

A simple logistic regression (Annexure II) shows that households with higher asset ownership have significantly higher odds of using LPG as an exclusive fuel. Even between primary and exclusive users of LPG, asset ownership remains a significant differentiating factor. This corroborates the findings of previous studies (Ranjan and Singh 2017) that state that households tend to switch their cooking fuel use patterns after a threshold level of income is achieved. However, this is not to suggest that all wealthy households shift to exclusive use of clean fuels. We discuss the reasons for stacking among these households in the next section.

Cooking energy in the household budget: We find that households using LPG as their only fuel pay INR 496 per month.[8] This effectively translates to an average household spending almost eight per cent of their monthly expenses on cooking fuel.

BOX 2 Uptake of small cylinders

Oil and Marketing Companies (OMCs) are attempting to address the challenges around the recurring refilling cost by encouraging low-income households to use a 5 kilograms (kg) cylinder to overcome the high upfront cost associated with 14.5kg cylinders. In our sample, we find that only about two per cent of urban slum households use small cylinders (5kg or 3kg).

8. This is based on the upfront cost paid by the household for an LPG refill. Given that only 40 per cent of the households' report receiving LPG subsidy on refills – it has not been considered in the fuel expenditure calculation. The share of fuel expenditure for the households receiving LPG subsidies would be accordingly less than the others.

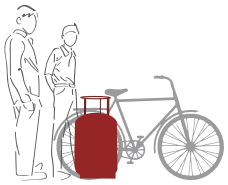
2.1.2 Home delivery for exclusive LPG users

We find that households who receive doorstep delivery of LPG refills have higher odds of using LPG as their exclusive fuel. Hassle-free doorstep delivery of LPG refills is known to influence the use of LPG as a primary, secondary, or exclusive fuel (PPAC-CRISIL 2016).

63%
LPG-using households receive doorstep delivery of cylinders

77%
households receiving doorstep delivery of LPG cylinders are exclusive users of the fuel

Additional expense on procurement of cylinders: Almost half of the households who receive doorstep delivery of LPG pay an additional amount of INR 20 as a delivery charge. However, in households that do not receive doorstep delivery, about 46 per cent report that one member must forgo their daily wages to procure the cylinder. Most of such households depend on daily labour or private jobs for their income.



Male members have to travel to procure the cylinders in 87% households

Given that almost half of the households report having to forgo wages to procure the cylinders, it could affect the household's ability to use LPG continually. It may add to the average delay in the purchase of refills.

Procurement of LPG cylinders during the COVID-19 pandemic: Most households that do not receive doorstep delivery of LPG (58 per cent) use private vehicles (including motorcycles or bicycles) to transport LPG refills. About one-third of the households procuring cylinders on their own use rented or shared vehicles. The procurement constraints faced by these households would be further aggravated during the COVID-19 pandemic, as using rented or shared vehicles comes with its own risks.

BOX 3 Status of slums impacting the fuel-use pattern

About 18 per cent of the respondents in our survey reported that they resided in non-notified slums. Such slums are not legally recognised as a 'slum' by the government, which makes the residents more vulnerable to eviction. In our data, we find that adoption and use of LPG is similar across households from notified and non-notified slums. Qualitative interviews and field visits showed that most of the respondents were permanent residents of the slums, who have been living there for more than 10 years.

BOX 4 Electricity for cooking

About 2 per cent of urban slum households use electricity as a source for cooking energy. These households do not rely on any other fuels for cooking or non-cooking purposes. They use electric stoves to prepare all meals, including cooking roti, rice, and vegetables. These households have been using electricity as their cooking fuel only in the past five years. Most households report using either a coiled stove or induction stove. Less than one per cent of households use other electric appliances such as hot water kettles and toasters for cooking needs.

2.2 Households stacking LPG with polluting fuels

Across the six states, almost half of the households (45 per cent) reported using polluting fuels. Here, we discuss the characteristics and fuel use patterns of households that stack clean and unclean fuels.

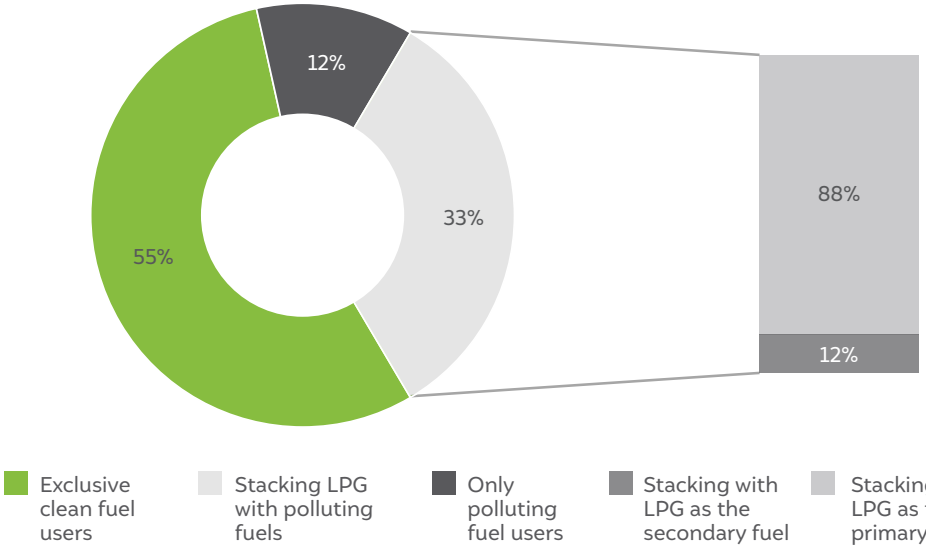


Figure 4
Of the households that stack fuels, most use LPG as their primary fuel

Source: Authors' analysis

Though 86 per cent of the households surveyed have an LPG connection, we find that over a third (33 per cent) of them stack it with polluting fuels (including firewood, dung cakes, agriculture residue, charcoal, and kerosene). The increased stacking could also be a result of more households adopting LPG, since households tend to not replace biomass-based fuels completely (Cheng and Urpelainen 2014). These households would need to transition to exclusive use of clean cooking fuels to reduce the health impacts on women and children from household air pollution.

About 44 per cent of the households that are stacking fuels rely on informal sources for refills. Such households have not ordered any refills in the past one year from their LPG distributors. These households mainly rely on recurring cylinders from their neighbours or relatives.[9]

BOX 5 Use of kerosene as a cooking fuel

About 4 per cent of urban slum households in the sample reported stacking with kerosene as their secondary fuel. Most of these households are in Uttar Pradesh. These households also use kerosene more than once a week for cooking.

9. It is important to note that sharing LPG cylinders among neighbours and extended family is a regular phenomenon in small towns and rural areas owing to availability challenges, and it is not necessarily driven by an intention to siphon off subsidy amounts against the commodity (Jain et al. 2018).

2.2.1 Household factors that determine the decision to stack fuels

Even within the stacking households, the reason for stacking multiple fuels varies significantly. Primarily, households who stack can be divided into two categories – those that stack as they cannot afford LPG refills, and those that stack due to other factors like taste preferences and alternate end-uses of the fuel.

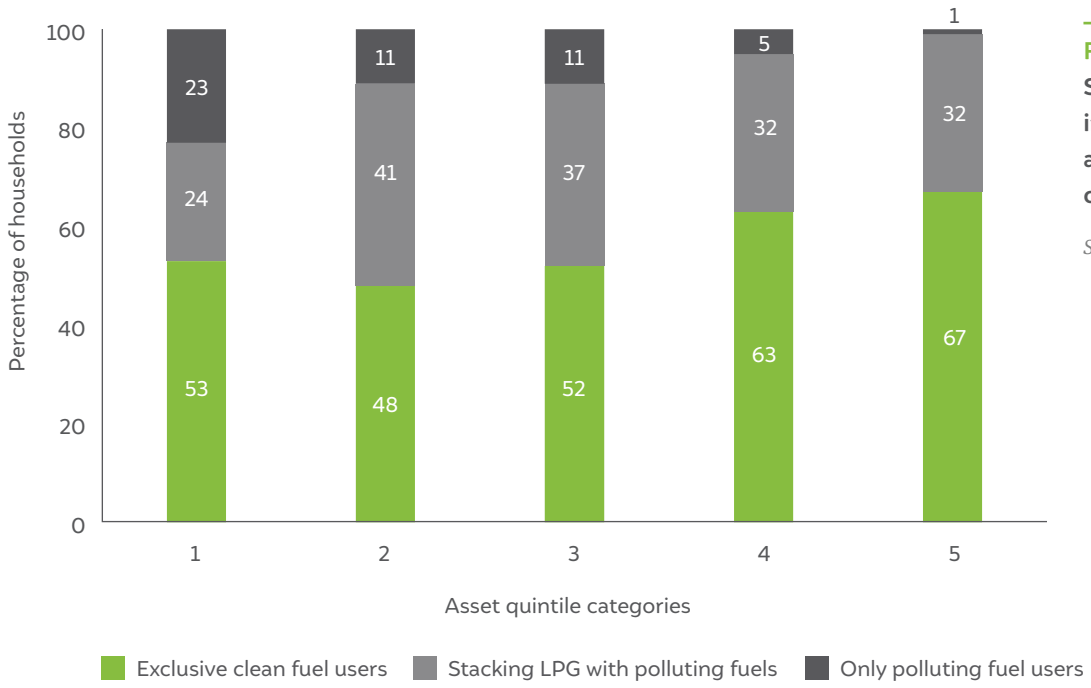


Figure 5
Stacking is prevalent in households across asset quintile categories

Source: Authors' analysis

Households who are stacking primarily due to affordability concerns – Across asset quintiles, we find that stacking is most common among the middle categories (second and third quintile), where most have adopted LPG. Still, the affordability of the fuel remains a significant concern. More than 60 per cent of the households that are stacking fuels collect or prepare firewood or dung cakes free of cost rather than purchasing them from the market. Those who buy biomass do not spend more than INR 100 per month on it. Based on the responses of the primary cook, we note that the high cost of LPG and free-of-cost availability of solid fuels are the most common factors that affect the fuel choices made by the household.

Households who use LPG primarily and polluting fuels as secondary fuels have a median annual refill rate of
6 cylinders

Households who use polluting fuels primarily and LPG as a secondary fuel have a median annual refill rate of
4 cylinders

Households that are stacking for reasons beyond affordability – More than one-fourth of the households that are stacking have a median annual refill rate of eight cylinders and above, despite having a similar household size as others. Most such households fall in the highest asset quintiles. This suggests that they are not necessarily using unclean fuels due to the unaffordability of LPG, but due to other factors such as taste, preference for chulhas, and fuel end-uses that influence the household's decision to use solid/polluting fuels. Such households reported using LPG for a median period of six years. The solid fuels are primarily used for cooking chapatis or vegetables in these households.

21%
households stacking fuels have more than one LPG connections

25%
households stacking fuels have two-cylinder connections

Interestingly, even households with multiple LPG connections and two cylinder connections report stacking with polluting fuels. The possession of multiple LPG connections in these households may not necessarily be an indicator of diversion — the average family size of these households is more than eight, indicating the high possibility of having separate kitchens within the same household. Given that such households have a median annual refill rate of ten cylinders, another plausible reason for multiple connections is that it prevents them from relying on just one distributor, which increases their chances of getting refills whenever needed.

2.2.2 End-uses of polluting fuels

Across both the groups discussed above, half of the households who stack with polluting fuels use these fuels at least once a day (Figure 6). Also, almost 45 per cent of the households that stack fuels use multiple stoves at the same time while preparing a single meal. This indicates that even if the household is using LPG for a particular meal, they would be using their *chulha* simultaneously.

Despite using LPG as the primary fuel for their cooking needs, households that are stacking fuels use polluting fuels for non-cooking purposes like heating water for bathing (29 per cent) and space heating (10 per cent).

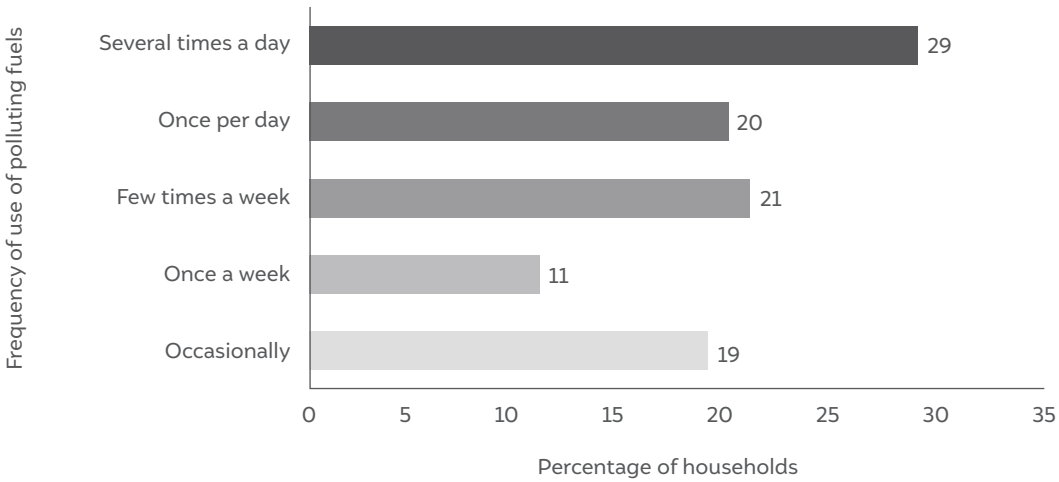


Figure 6
Almost half of the households using polluting fuels use it every day

Source: Authors' analysis

2.2.3 Seasonal variations in the stacking of fuels

We also noted a significant seasonal change in fuel use patterns. LPG is most popular in the rainy season (88 per cent) and least popular in the winter months (45 per cent) (Figure 7). The dampness associated with solid fuels in the rainy season could be the reason for using LPG primarily during these months. The literature also suggests that solid fuels are a popular choice during winter months (S. Singh 2014; Baqir et al. 2019). This could be because, during winter months, the solid fuel requirement for non-cooking tasks within the household likes water heating for bathing and space heating increases. Since households are already using solid fuels for non-cooking tasks, they may be using these fuels more for cooking during winter. Unfortunately, the increased use of solid fuels in winter exacerbates the much higher air pollution exposure of these households due to unfavourable atmospheric conditions.

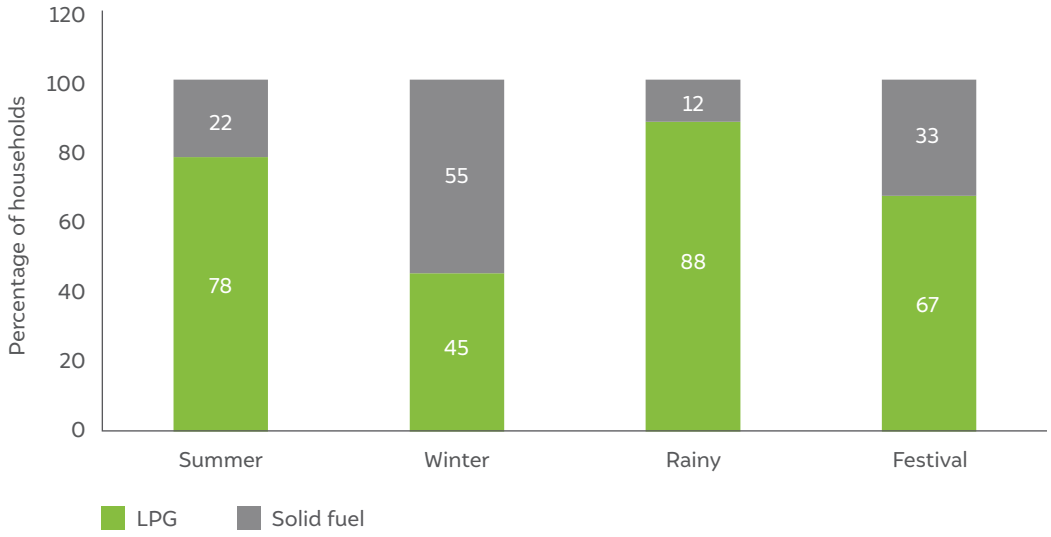


Figure 7
Proportion of urban slum households using solid fuels as the primary cooking fuel increases during the winters months, aggravating household air pollution exposure due to unfavourable atmospheric conditions

Source: Authors' analysis

BOX 6 Electric devices for water heating and space heating

About 3 per cent of urban slum households reported owning an electric water-heating device (geyser or immersion rod). Similarly, only 4 per cent of the households own an electric room heater.

Connections under the *Pradhan Mantri Ujjwala Yojana (PMUY)*

23 per cent of these households reported receiving benefits under the PMUY.

The six states included in the survey account for a significant share of *PMUY* coverage – 54 per cent of all connections provided under *PMUY* (PPAC 2019). However, most of these connections cater to rural households. One of the reasons for there being fewer *PMUY* connections in urban areas is that more than half of all urban slum households reported already having had LPG connections for over four years (before the launch of *PMUY*). Moreover, over a quarter of *PMUY* households[10] in urban slums reported having multiple LPG connections, which suggests that not every household which was using LPG before the *PMUY* was prevented from accessing the scheme's benefits.

Government support during the COVID-19 pandemic: During the COVID-19 lockdown, the government announced the provision of three free-of-cost refills for *PMUY* households under the *PM-Garib Kalyan Yojana*. While *PMUY* households in urban slums benefitted from this scheme, non-PMUY households in urban slums did not. As documented, urban slum households faced a significant economic hit due to the loss of jobs and incomes during the pandemic (Patel 2020). Non-*PMUY* households that stack for economic reasons are more likely to use cheaper and freely available solid fuels without additional support from the government.

PAHAL-Direct Benefit Transfer for LPG (DBTL)

Overall, about 42 per cent of active LPG users[11] reported receiving a subsidy for their last LPG refill under the *Direct Benefit Transfer for LPG* scheme (DBTL). However, about 28 per cent of urban slum households reported not knowing if they had received the subsidy amount for their last refill; this suggests that the primary cook is often unaware of whether the subsidy is credited to the household. Among the ones that reported receiving the LPG subsidy, about 40 per cent of the primary cook were not aware of the amount of subsidy being credited into their account.

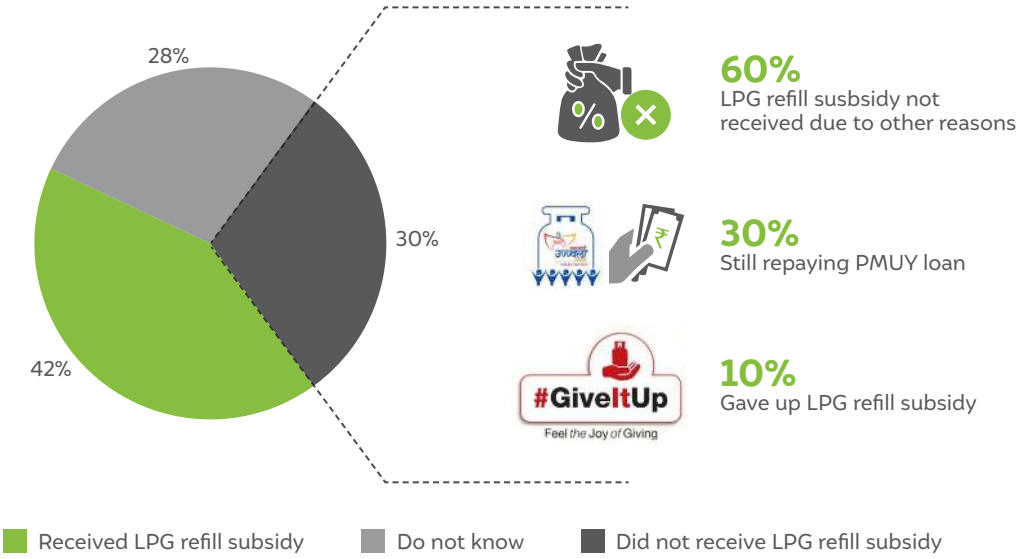


Figure 8
Lack of awareness about receiving LPG refill subsidies poses a threat to the success of LPG subsidy schemes

Source: Authors' analysis

10. This is a relatively smaller sample of 43 households from all the PMUY households in urban slums (131 households).

11. Households that have taken at least one refill in the past year.

2.3 Households using only polluting fuels

About 12 per cent of urban slum households rely entirely on polluting fuels for all cooking and non-cooking purposes. While the share of these households is relatively small, the non-adoption of LPG in such households despite programmes like the *PMUY* is concerning. These households either use a combination of different polluting fuels (firewood, dung cakes, agricultural residue, charcoal, and kerosene), or just one of these fuels for all their energy needs. Firewood is the most commonly used fuel in these households.

2.3.1 Reasons for the non-adoption of LPG

Households that rely exclusively on polluting fuels reported not having an LPG connection. Though three-fourths of these households were aware of *PMUY*, the high upfront cost of an LPG connection, along with the high recurring cost of procuring refills, remain the two most important reasons for not procuring an LPG connection. Repondents also mentioned a lack of information on how to procure a connection as a reason. These reasons align with the common causes cited by rural households covered in the survey, implying that the challenges faced by rural households and urban slum households in procuring connections are similar.

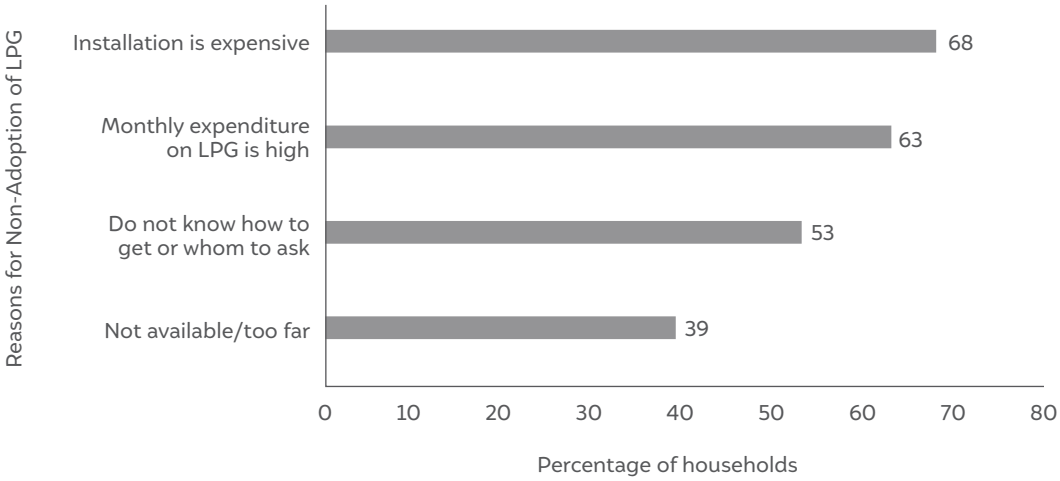


Figure 9
More than half of the households currently without LPG do not know how to get a connection or whom to ask about it, implying a lack of awareness

Source: Authors' analysis

Almost half of the households in this category use solid fuels for non-cooking purposes such as heating water for bathing, space heating, and preparing fodder for animals. On the positive aspects of using polluting fuels, households reported the following: free-of-cost, easy availability of fuels, better tasting food, and preference of family members for food cooked on the *chulha*.

2.3.2 Fuel availability and affordability

In contrast with households that stack fuels, households that use only solid fuels rely on purchasing fuels rather than collecting or preparing them. For instance, 60 per cent of firewood users in this category procure fuel by purchasing rather than collecting it.

Households with low asset ownership rely on polluting fuels for cooking. These households spend 2–3 per cent of their median monthly expenditure on fuel (INR 75 per month on fuel), which is much lower than what they would have to spend if they used LPG exclusively (INR 496 per month). Households that collect solid fuels spend about two hours on a single trip (three times a month), travelling a median one-way distance of 2 km. This is equivalent to the distance travelled to procure LPG cylinders (if not delivered at home).

2.3.3 Gendered time use in households using solid fuels

In urban slums, both, the male and female members of the household, are equally involved in collecting firewood. Still, it is primarily the female members of the household who undertake dung cake preparation. In addition to engaging in fuel collection and preparation, women tend to spend more time cooking in households using solid fuels. About 85 per cent of households that transitioned to LPG in the past four years reported having saved time while cooking compared to when they used solid fuels.

SPOTLIGHT I: Household air pollution (HAP) in urban slums

Image: iStock

Winter months have the highest PM2.5 concentrations coinciding with the sharp increase in use of polluting fuels for heating bath water and room heating

Burning solid fuels in three-stone fires and mud stoves with inadequate ventilation causes high levels of smoke exposure and negative health impacts, particularly for women and young children (WHO 2014).

The double burden of ambient and household air pollution on the urban slum population

Using the PM2.5 data from continuous ambient air quality monitoring stations (CAAQMS) for 15 districts[12] in our sample, we found that the ambient air quality remained in the 'poor' or worse category[13] for most districts throughout the year. variation in the ambient air quality;

12. See Annexure III for details on the districts and their PM2.5 concentrations. The data for 15 districts (from Bihar, Uttar Pradesh, Madhya Pradesh, and Rajasthan) overlapping with the survey sample have been analysed based on the availability of air quality data from continuous monitoring stations.

13. Air quality categories based on PM2.5 concentration (in µg/m^3):

    Good: 0 to 30
    Satisfactory: 31 to 60
    Moderately polluted: 61 to 90
    Poor: 91 to 120
    Very poor: 121 to 250
    Severe: above 250 (Central Pollution Control Board 2014)

the winter months (November to February) have the highest concentration of PM2.5. This leads to a double burden of exposure for slum households stacking solid fuels, as they are more likely to increase use of solid fuels in winters (Figure 7). Alternatively, the use of LPG as the primary source of fuel increases during the rainy season (June to September); these months record the least ambient air pollution.

We also find that districts like Meerut, Ghaziabad, Patna, Gautam Buddha Nagar (Noida and Greater Noida), and Muzaffarpur have the highest frequency of 'very poor' air quality days throughout the year. Across these districts, one-third of households use polluting fuels for cooking. In urban slums, where households are more densely packed, the emissions from burning solid fuels increase the risk of exposure inside households and deteriorate the ambient air quality for the community at large. As a result, these communities suffer from both increased household and ambient air pollution. HAP has an estimated average contribution of 30–50 per cent to ambient air quality across India's urban and rural areas (Balakrishnan et al. 2019). Addressing biomass burning for cooking, water heating, and space heating during the winters has the potential to help reach the national ambient air quality standards (Chowdhury et al. 2019). Despite that only 2 per cent of the action points in 44 city clean air plans mention cooking and heating as a sector to address air pollution (Ganguly, Selvaraj and Guttikunda 2020).

Impact of ventilation

75%
households' using polluting fuels cook inside the main house

67%
households' using polluting fuels do not have a chimney for ventilation

Indoor cooking and low adoption of chimney indicates high exposure to pollution from the use of unclean fuels for cooking. The proportion of households with a chimney is high (52 per cent) among those who rely only on polluting fuels. Smith and Pillarisetti (2017) explain that while having a good chimney lowers peak levels of indoor pollution, long-term average exposure is reduced only by a factor of two. Besides, chimneys require regular maintenance to function correctly. While more than 45 per cent of the households are using polluting fuels, less than 20 per cent of the slum housheolds use improved cookstoves.

Households also use solid fuels for non-cooking uses like space heating. On average, each house in a slum has two rooms; this effectively exposes all members of the household to emissions from burning fuels. Emissions from household sources contribute significantly to the surrounding air quality (Harish et al. 2019); this concern is exacerbated in congested slum areas.

Awareness about the health impacts of using polluting fuels

About 60 per cent of households using only polluting fuels, and 84 per cent of households that stack LPG with a polluting fuel, report 'too smoky' as the most prominent negative aspect of using polluting fuels. This suggests that as more households switch to clean cooking fuels, perceptions regarding pollution fuels change.

Three-fourths of primary cooks who use polluting fuels for cooking agree that smoke from solid fuels is harmful to them; this implies that awareness of the adverse health impacts of polluting fuels does not necessarily lead to the uptake of clean fuels. Primary cooks also agree that smoke from solid fuels causes coughing (49 per cent) and lung infections in children (39 per cent).

BOX 7 Impact of household air pollution on COVID-19

Exposure to air pollution is a known risk factor for underlying chronic diseases that predict the severity of COVID-19 disease and patient outcomes (World Bank 2020). This linkage suggests a heightened risk for women in all age groups who cook using traditional technologies and fuels (World Bank 2020). The highest number of COVID-19 cases were recorded in the most polluted regions, among patients with pre-existing health conditions (Frontera et al. 2020).

Results from a controlled study show a higher prevalence of chronic obstructive pulmonary disease (COPD) among biomass fuel users than clean fuel users (Johnson et al. 2011). The available clinical data to date suggest that cardiovascular disease, diabetes, chronic respiratory illness, and hypertension – conditions all strongly associated with exposure to HAP – are also risk factors for COVID-19 (World Bank 2020).

SPOTLIGHT II: Women's participation in intra-household decision-making regarding LPG use


Image: CEEW

Traditionally, women bear a disproportionate burden in collecting and preparing biomass for cooking. While this burden reduces with the use of clean cooking fuels like LPG, the fuel supply within the household is then determined by formal and monetised distribution networks involving an outlay of money (Patnaik and Jha 2020). Our data shows that women's status in the household (as heads of households)[14] positively correlates with households using LPG as their primary fuel. The existing literature also supports the idea that female-headed households prefer modern fuels to polluting ones (Farsi, Filippini, and Pachauri 2007; Rao and Reddy 2007; Kuo and Azam 2019). Other research also suggests that female-headed households are more willing to spend on LPG as a recurring expense (Kojima, Bacon, and Zhou 2011; Kuo and Azam 2019).

50%
households' female members decide whether or when to purchase LPG refills

30%
households' female members place the order for LPG refills

14. In almost half of the households surveyed, the primary cook reported a female member being the head of the household. The reason behind such high percentage of female-headed households could be because only the primary cook of every household (who is mostly female) was surveyed. This does not mean that these households do not have any adult male members. Traditionally, headship refers to the head of household as the individual whose 'authority' the household members recognise. But this definition overlooks potential intra-household variations in the recognised authority in different realms of decision-making (Kilic, Moylan, and Koolwal 2020). Since cooking is a gendered activity, the primary cook's response to the head of household question may have been with respect to the recognised authority figure for that activity within the household.

We also find that the decision of whether or when to purchase LPG refills is made by male members in half of urban slum households. This holds for both male- and female-headed households. In LPG-using households where the primary cook is involved in an income-generating activity, more women are deciding to order the refills. This pattern is similar irrespective of whether the household uses LPG exclusively or stacks it with other polluting fuels or are *PMUY* beneficiaries.

BOX 8 Variations in intra-household decision-making across states and caste groups

At the state level, Bihar has significantly poor involvement of women in intra-household decision-making regarding ordering refills, with less than 10 per cent of households reporting that women decide whether or when to order refills. However, more women than men are involved in decisions around LPG refills in Rajasthan, Madhya Pradesh, and Jharkhand.

Across caste groups, the involvement of women is lowest (37 per cent) among the Scheduled Castes (SCs). However, more women in General and OBC households decide when to order LPG refills.

SPOTLIGHT III: A comparison of access to clean cooking energy between urban slum and non-slum households across six states

Image: iStock

To compare the fuel use patterns of urban slum and non-slum households, we used data from the *India Residential Energy Survey* (IRES 2020).[15] The overlap in the sampling strategies of both IRES and our survey enabled a comparison of the findings. There is a significant difference in the socio-economic status of slum and non-slum households, which tends to affect their fuel use patterns. Table 4 provides a comparison of cooking fuel usage in urban non-slum households (from IRES 2020) and urban slum households (*Cooking Energy Access and Use* survey 2020).

Fuel use categories	Non-slum urban households (IRES) (%)	Urban slum households (Cooking Energy Access Survey) (%)
Clean fuel users (LPG, PNG, and electricity)	95	88
LPG as an exclusive fuel	84	55
Households that stack LPG with polluting fuels	9	33
Households that use only polluting fuels	5	12

Table 4
The poor economic condition of households in urban slums impacts the exclusive use of clean fuels for cooking

Source: Authors' analysis

We observed a significant gap in the exclusive use of LPG as a cooking fuel between urban slums and non-slum households, explained mainly by the difference in their economic conditions. Stacking is three times more common in slum households than non-slum households. About 45 per cent of non-slum households using polluting fuels belong to marginalised social groups (SCs and STs). Households using polluting fuels have a lower median monthly expenditure than others, and about 62 per cent of such households are semi-*pucca* or *kuchha* structures. Among LPG users, non-slum households have a slightly higher rate of doorstep delivery as compared to slum households.

	Non-slum urban households *(IRES)* (%)	Urban slum households *(Cooking Energy Access and Use)* (%)
LPG-using households receiving home deliveries	72	63
Proportion of PMUY beneficiaries among LPG-using households	9	23

Source: Authors' analysis

15. IRES 2020 was conducted in 21 large states of India including Bihar, Jharkhand, Rajasthan, Madhya Pradesh, Uttar Pradesh, and Chhattisgarh. While IRES 2020 focused on urban households, the Cooking Energy Access and Use survey specifically attended to urban slums in the same districts. Refer to the technical note for a detailed methodology of the survey.

3. Way forward

Image: iStock

Slums across the world are chronically ignored in public policy and suffer because of unauthorised and unsafe habitation without access to government services (Shahadat, Lipu, and Bhuiyan 2014). In terms of energy access, while we see a progressive change in households' energy use patterns as we move from rural to urban, issues like affordability, availability, preference, and familiarity with the fuel and stove remain essential factors that determine households' fuel choice.

Understanding categories of users is important for enabling access to and use of clean cooking fuels

We categorised the urban slum population based on their fuel usage patterns – using only clean fuels, stacking clean fuels with polluting fuels, and using only polluting fuels. While most households in urban slums have an LPG connection, only half of them use LPG exclusively. The household's economic status and its access to doorstep delivery of LPG refills are two crucial factors that determine its ability to use LPG exclusively. Despite being situated in urban areas, 37 per cent of slum households do not receive home delivery of cylinders – availability is an essential factor in determining the household's likelihood of using LPG exclusively. There is a strong impetus for the OMCs and distributors to improve their home delivery services of LPG refills in slum areas.

Stacking is prevalent in about one-third of households – there is a need for a deeper understanding of households' preferences, fuel end-uses, and awareness. Most households reported using polluting fuels daily or at least weekly; this effectively increases their exposure to household air pollution despite having access to clean cooking fuels. Among households that stack LPG with polluting fuels, the reasons for stacking differ – affordability, seasonality, and taste preference. More than a quarter of households that stack have a similar level of LPG consumption as those that use LPG exclusively despite similar family sizes. Such households use polluting fuels not because of their inability to afford LPG. But other factors, like free-of-cost availability of biomass, taste, preference for chulha, and alternate end-uses of fuel—for instance, in space heating—influence the household's decision to use solid fuels. Among households that stack multiple fuels, the use of polluting fuels increases during winter months; this exposes the households to a double burden of high ambient and household air pollution in these months. About 40 per cent of these households also use polluting fuels for non-cooking purposes like heating water for bathing and space heating, especially in winter.

Access to clean cooking energy schemes must be integrated into the social assistance programmes focused on urban poverty alleviation to enhance its reach

Even with large-scale government initiatives like *PMUY*, we find that more than 10 per cent of urban slum households do not use LPG. They mainly rely on free-of-cost biomass for their cooking and non-cooking needs. Despite awareness of *PMUY* among these households, the high upfront cost of procuring an LPG connection and high recurring expenditure on refills deter them from using LPG. Evidently, there is a need to expand the reach of *PMUY* to cover households across slums.

Integrating the issue of lack of access to clean cooking energy within the discussion on urban poverty

This study reiterates the need to look at poverty in urban areas in the context of energy access. Given the heterogeneity of poverty in urban and semi-urban India, it is essential to understand energy poverty in the context of access to resources for an enhanced quality of life for the urban poor. Similarly, slums dwellers in large and small cities alike may experience additional challenges of access. Furthermore, not all urban poor live in slums; we know even less about the access issues of temporary residents or seasonal migrants in urban India. Therefore, in a rapidly urbanising India, studies on the urban poor and air quality need to integrate a focus on energy access to address the vulnerability of women, children, and communities to HAP and the drudgery of using polluting fuels for cooking and other household energy needs.

Converging energy access in social protection policies for the urban poor

Accounting for the vulnerabilities of the urban poor is crucial in designing and implementing policies, including social protection schemes. As a health and economic imperative, access to clean cooking energy schemes must be integrated into the social assistance programmes of other ministries (e.g., health, education, and nutrition assistance) to offer better support to slum households. This would also reduce the burden on households of claiming and accessing multiple benefits across schemes, thus freeing them to invest more time in productive activities (CEEW 2020). Government programmes such as the *National Urban Livelihoods Mission* and social service allocations for housing should use existing targeting approaches to include access to clean cooking energy within the ambit of services for the poor.

There is a need to target vulnerable households – beyond *PMUY* beneficiaries – with differential subsidy support for using LPG in a sustained manner

Bringing a renewed emphasis on clean cooking energy access due to COVID-19 is essential

Most households in urban slums rely on daily wage labour or the gig economy for their household income. During the COVID-19 pandemic, these occupations have been among the worst impacted by the lockdown and the economic slowdown. A survey conducted with over 2,000 daily wage workers in urban slums during the lockdown suggests that only 7 per cent of respondents from this group received pay during the lockdown (Basu 2020), causing a massive shock to their livelihoods and wage earnings. This kind of impact pushes households into energy poverty, leading to the increased use of free-of-cost biomass and consequently increasing the risk of exposure to emissions from fuel burning. While the government has committed to supplying up to three free refills to all *PMUY* households under *PM-Garib Kalyan Yojana*, less than a quarter of households in urban slums have *Ujjwala* connections. The low share of *PMUY* households effectively makes the majority of slum households ineligible for relief support given under the *PM-Garib Kalyan Yojana* during the lockdown. There is a need to target vulnerable households – beyond *PMUY* beneficiaries – with differential subsidy support for using LPG in a sustained manner.

Increased poverty would mean increased use of polluting fuels – there is a need for a renewed emphasis on clean cooking energy access during the COVID-19 pandemic as increased use of polluting fuels has health implications (lower respiratory infections and COPD) that increase the risk of COVID-19 infections being more severe.

References

Balakrishnan, Kalpana, Sagnik Dey, Tarun Gupta, R. S. Dhaliwal, Michael Brauer, Aaron J. Cohen, Jeffrey D. Stanaway, et al. 2019. "The Impact of Air Pollution on Deaths, Disease Burden, and Life Expectancy Across the States of India: The Global Burden of Disease Study 2017." *The Lancet Planetary Health* 3 (1): e26–39. https://doi.org/10.1016/S2542-5196(18)30261-4.

Baqir, M., S. K. Bharti, R. Kothari, and R. P. Singh. 2019. "Assessment of an Energy-efficient Metal Chulha for Solid Biomass Fuel and Evaluation of its Performance." *International Journal of Environmental Science and Technology* 16 (11): 6773–6784. https://doi.org/10.1007/s13762-018-2028-9.

Basu, Anika Badyal. 2020. "Lockdown Survey: How The Covid-19 Crisis Has Affected Daily Wage Workers—AIF." *American India Foundation*, June 28. https://aif.org/lockdown-survey-how-the-covid-19-crisis-has-affected-daily-wage-workers/.

Butera, F. M., P. Caputo, R. Adhikari, and A. Facchini. 2016. "The Challenge of Energy in Informal Settlements: A Review of the Literature for Latin America and Africa." *Procedia Engineering*: 1–32. https://www.enelfoundation.org/content/dam/enel-found/topic-download/The challenge of Energy in Informal settlements.pdf.

CEEW. 2020. "Energy Safety Nets: India Case Study." Vienna: Sustainable Energy for All. https://www.ceew.in/publications/energy-safety-nets-india-case-study.

Central Pollution Control Board. 2014. "National Air Quality Index." New Delhi: Central Pollution Control Board. https://app.cpcbccr.com/ccr_docs/FINAL-REPORT_AQI_.pdf.

Chafe, Z., S. Mehta, and K. R. Smith. 2011. "Ambient Fine Particulate (PM2.5) Air Pollution Attributable to Household Cooking Fuel in Asia." *AGUFM*: A54B–03. https://ui.adsabs.harvard.edu/abs/2011AGUFM.A54B..03C/abstract.

Chandramouli, C. 2010. "Census of India 2011 – Circular No. 8." New Delhi: Ministry of Home Affairs. https://censusindia.gov.in/2011-Circulars/Circulars/Circular-08.pdf.

Chandrasekhar, S., and Arup Mitra. 2018. "Migration, Caste and Livelihood: Evidence from Indian City-slums." *Urban Research & Practice* 12 (2): 156–172. https://doi.org/10.1080/17535069.2018.1426781.

Cheng, Chao Yo, and Johannes Urpelainen. 2014. "Fuel Stacking in India: Changes in the Cooking and Lighting Mix, 1987–2010." *Energy* 76 (November): 306–317. https://doi.org/10.1016/j.energy.2014.08.023.

Chowdhary, Sourangsu, Sagnik Dey, Sarath Guttikunda, Ajay Pillarisetti, Kirk R. Smith, and Larry Di Girolamo. 2019. "Indian annual ambient air quality standard is achievable by completely mitigating emissions from household sources" *Proceedings of the National Academy of Sciences* 116 (22) 10711-10716. https://doi.org/10.1073/pnas.1900888116.

Dhingra, Chhavi, Shikha Gandhi, Akanksha Chaurey, and P. K. Agarwal. 2008. "Access to Clean Energy Services for the Urban and Peri-Urban Poor: A Case-study of Delhi, India." *Energy for Sustainable Development* 12 (4): 49–55. https://doi.org/10.1016/S0973-0826(09)60007-7.

Farsi, Mehdi, Massimo Filippini, and Shonali Pachauri. 2007. "Fuel Choices in Urban Indian Households." *Environment and Development Economics* 12 (6): 757–774. https://doi.org/10.1017/S1355770X07003932.

Frontera, Antonio, Lorenzo Cianfanelli, Konstantinos Vlachos, Giovanni Landoni, and George Cremona. 2020. "Severe Air Pollution Links to Higher Mortality in COVID-19 Patients: The 'Double-Hit' Hypothesis." *Journal of Infection* 81 (2): 255–259. https://doi.org/10.1016/j.jinf.2020.05.031.

Ganguly, Tanushree, Kurinj L. Selvaraj, Sarath K. Guttikunda. 2020. "National Clean Air Programme (NCAP) for Indian cities: Review and outlook of clean air action plans." Atmospheric Environment: X, Vol 8 . https://doi.org/10.1016/j.aeaoa.2020.100096.

GNESD. 2008. "Clean Energy for the Urban Poor: An Urgent Issue." Accessed 25 July 2020 https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwi1hf2rudntAhUCOisKHQH7BtsQFjAAegQIAxAC&url=http%3A%2F%2Fwww.gnesd.org%2F-%2Fmedia%2FSites%2FGNESD%2FPublication- pdfs%2FSPM_CleanEnergy.ashx%3Fla%3Dda%26hash%3DE4971C585B6798F17954F8B42E073D9507F42A84&usg=AOvVaw08kCDgOkTkYc6wRDxzsNyq.

Guan, Wei-Jie, Wen-Hua Liang, Yi Zhao, Heng-Rui Liang, Zi-Sheng Chen, Yi-Min Li, Xiao-Qing Liu, et al. 2020. "Comorbidity and its Impact on 1590 Patients with COVID-19 in China: A Nationwide Analysis." *European Respiratory Journal* 55 (5): 2000547. https://doi.org/10.1183/13993003.00547-2020.

Harish, Santosh, Kirk R. Smith, Sourangsu Chowdhury, Zoe A. Chafe, Ajay Pillarisetti, Jos Lelieveld, Sarath Guttikunda, Sagnik Dey, and Andrew P. Grieshop. 2019. "The Contribution of Household Fuels to Ambient Air Pollution in India: A Comparison of Recent Estimates Edited by Ccapc.Org.In." *Collaborative Clean Air Policy Centre*, May 30. https://ccapc.org.in/policy-briefs/2019/5/30/the-contribution-of-household-fuels-to-ambient-air-pollution-in-india-a-comparison-of-recent-estimates.

Jain, Abhishek, Saurabh Tripathi, Sunil Mani, Sasmita Patnaik, Tauseef Shahidi, and Karthik Ganesan. 2018. "Access to Clean Cooking Energy and Electricity: Survey of States 2018." New Delhi: CEEW. https://www.ceew.in/sites/default/files/CEEW-Access-to-Clean-Cooking-Energy-and-Electricity-11Jan19_0.pdf.

Johnson, Priscilla, Kalpana Balakrishnan, Padmavathi Ramaswamy, Santu Ghosh, Muthukumar Sadhasivam, Omprakash Abirami, Bernard W. C. Sathiasekaran, Kirk R. Smith, Vijayalakshmi Thanasekaraan, and Arcot S. Subhashini. 2011. "Prevalence of Chronic Obstructive Pulmonary Disease in Rural Women of Tamilnadu: Implications for Refining Disease Burden Assessments Attributable to Household Biomass Combustion." *Global Health Action* 4 (1): 7226. https://doi.org/10.3402/gha.v4i0.7226.

Kilic, Talip, Heather Moylan, and Gayatri Koolwal. 2020. "Getting the (Gender-disaggregated) Lay of the Land: Impact of Survey Respondent Selection on Measuring Land Ownership and Rights." Washington DC: The World Bank. https://doi.org/10.1596/1813-9450-9151.

Kojima, Masami, Robert Bacon, and Xin Zhou. 2011. "Who Uses Bottled Gas? Evidence from Households in Developing Countries." The World Bank Sustainable Energy Department Oil, Gas, and Mining Unit. http://elibrary.worldbank.org/doi/book/10.1596/1813-9450-5731.

Kuo, Ying-Min, and Mehtabul Azam. 2019. "Household Cooking Fuel Choice in India, 2004–2012: A Panel Multinomial Analysis." *IZA Discussion Paper No. 12682*. https://ssrn.com/abstract=3468630.

Lippi, Giuseppe, and Brandon Michael Henry. 2020. "Chronic Obstructive Pulmonary Disease Is Associated with Severe Coronavirus Disease 2019 (COVID-19): COPD and COVID-19." *Respiratory Medicine* 167: 105941. https://doi.org/10.1016/j.rmed.2020.105941.

Ministry of Housing and Urban Affairs. 2019. "Handbook of Urban Statistics." New Delhi: Government of India. http://mohua.gov.in/pdf/5c80e2225a124Handbook of Urban Statistics 2019.pdf.

Rao, M. Narasimha, and B. Sudhakara Reddy. 2007. "Variations in Energy Use by Indian Households: An Analysis of Micro Level Data." *Energy* 32 (2): 143–153. https://doi.org/10.1016/j.energy.2006.03.012.

National Buildings Organisation. 2013. "State of Slums in India a Statistical Compendium 2013." New Delhi: Government of India. http://nbo.nic.in/pdf/Slums_in_India_Compendium_English_Version.pdf.

National Sample Survey Office. 2012. "Key Indicators of Urban Slums in India – 69th Round." New Delhi: National Data Bank for Socio-religious Categories. http://mospi.nic.in/sites/default/files/national_data_bank/ndb-rpts-69.htm.

Nolan, Laura B. 2015. "Slum Definitions in Urban India: Implications for the Measurement of Health Inequalities." *Population and Development Review* 41 (1): 59–84. https://ideas.repec.org/a/bla/popdev/v41y2015i1p59-84.html.

Nolan, Laura B., David E. Bloom, and Ramnath Subbaraman. 2018. "Legal Status and Deprivation in Urban Slums Over Two Decades." *HHS Public Access* 53 (15): 47–55.

Patel, Amit. 2020. "Preventing COVID-19 Amid Public Health and Urban Planning Failures in Slums of Indian Cities." *World Medical & Health Policy* 12 (3). https://doi.org/10.1002/wmh3.351.

Patnaik, Sasmita, and Shaily Jha. 2020. "Caste, Class and Gender in Determining Access to Energy: A Critical Review of LPG Adoption in India." *Energy Research & Social Science* 67 (September): 101530. https://doi.org/10.1016/j.erss.2020.101530.

PPAC-CRISIL. 2016. "Assessment Report: Primary Survey on Household Cooking Fuel Usage and Willingness to Convert to LPG." New Delhi: Petroleum Planning & Analysis Cell, Ministry of Petroleum and Natural Gas, Government of India. https://www.ppac.gov.in/WriteReadData/Reports/201710310449342512219PrimarySurveyReportPPAC.pdf.

PPAC. 2019. "Oil Industry Information at a Glance." New Delhi: Ministry of Petroleum and Natural Gas, Government of India. https://www.ppac.gov.in/WriteReadData/Reports/201912060336500305462ReadyReckonerNov2019WebVersion.pdf.

Rahaman, Mehebub, and Dipendra Nath Das. 2017. "Nature of Slum Growth in Indian Cities." *Urban India* 37 (II): 100–116. https://www.researchgate.net/publication/334051882_Nature_of_Slum_Growth_in_Indian_Cities#read.

Rains, Emily, Anirudh Krishna, and Erik Wibbels. 2018. "Urbanisation and India's Slum Continuum: Evidence on the Range of Policy Needs and Scope of Mobility." London: International Growth Centre. https://www.theigc.org/wp-content/uploads/2018/02/Rains-et-al_Working-paper_cover.pdf.

Ranjan, Rahul, and Sudershan Singh. 2017. "Energy Deprivation of Indian Households: Evidence from NSSO Data." New Delhi: Munich Personal RePEc Archive. https://mpra.ub.uni-muenchen.de/83566/1/MPRA_paper_83566.pdf.

Roy, Debraj, Bharath Palavalli, Niveditha Menon, Robin King, Karin Pfeffer, Michael Lees, and Peter M. A. Sloot. 2018. "Survey-based Socio-economic Data from Slums in Bangalore, India." *Nature Publishing Group* 5: 1–9. https://doi.org/10.1038/sdata.2017.200.

Saksena, Sumeet, P. B. Singh, Raj Kumar Prasad, Rakesh Prasad, Preeti Malhotra, Veena Joshi, and R. S. Patil. 2003. "Exposure of Infants to Outdoor and Indoor Air Pollution in Low-income Urban Areas: A Case Study of Delhi." *Journal of Exposure Science & Environmental Epidemiology* 13: 219–30. https://doi.org/10.1038/sj.jea.7500273.

Lipu, Molla Shahadat Hossain, and Arif Waliullah Bhuiyan. 2014. "Electricity Access in Urban Slum Households of Bangladesh: A Case of Dhaka." *Journal of Renewable and Sustainable Energy* 6 (053112): 1–15. https://doi.org/10.1063/1.4896697.

Singh, Rozita, Xiao Wang, Emmanuel Ackom, and Juan Reyes. 2015. "Energy Access Realities in Urban Poor Communities of Developing Countries: Assessments and Recommendations." Global Network on Energy for Sustainable Development (GNESD). https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwj5nbqIwdntAhXUTXoKHZE6DboQFjAAegQIAhAC&url=https%3A%2F%2Forbit.dtu.dk%2Ffiles%2F106352494%2FEnergy_access_realities_v_final_updated.pdf&usg=AOvVawoxNBAAoobjLueY9FmoigKF.

Singh, Santosh. 2014. "The Kaleidoscope of Cooking: Understanding Cooking Behaviour and Stove Preferences in Rural India." New Delhi: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. https://www.giz.de/en/downloads/giz2014-en-kaleidoscope-of-cooking-india.pdf.

Smith, Kirk R., and Ajay Pillarisetti. 2017. "Household Air Pollution from Solid Cookfuels and its Effects on Health." *Disease Control Priorities* 7 (3): 133–52. https://doi.org/10.1596/978-1-4648-0522-6_ch7.

UN-Habitat. 2003. "The Challenge of Slums – Global Report on Human Settlements 2003." Location of publishing: London. UN-Habitat. https://unhabitat.org/the-challenge-of-slums-global-report-on-human-settlements-2003.

Wang, Bolin, Ruobao Li, Zhong Lu, and Yan Huang. 2020. "Does Comorbidity Increase the Risk of Patients with COVID-19: Evidence from Meta-analysis." *Aging* 12 (7): 6049–6057. https://doi.org/10.18632/AGING.103000.

WHO. 2014. "WHO Guidelines for Indoor Air Quality: Household Fuel Combustion." *WHO*. Accessed 25 July 2020. http://www.who.int/airpollution/guidelines/household-fuel-combustion/en/.

World Bank. 2020 "The State of Modern Energy Cooking Services." Washington DC: World Bank. http://documents1.worldbank.org/curated/en/937141600195758792/pdf/The-State-of-Access-to-Modern-Energy-Cooking-Services.pdf.

Yenneti, Komali, Yehua Dennis Wei, and Wen Chen. 2017. "The Urbanization of Poverty in India: Spatio-temporal Disparities in Consumption Expenditures." *Geographical Review* 107 (2): 360–383. https://doi.org/10.1111/j.1931-0846.2016.12167.x.

Annexures

Annexure 1

Asset ownership index

We used Filmer and Pritchett's (2001) proposed approach to construct an asset ownership index using principal component analysis (PCA). We chose the indicators based on data from the *Cooking Energy Access* survey 2020. The variables we considered for the index were based on classifications by Caroline Moser and Andrew Felton (2007) and K. Harttgen (2013). We computed the asset index using housing characteristics and consumer durables as follows:

Housing characteristics	• Crowding[16] inside the house
	• Toilet ownership and usage
	• Source of water
	• Number of pucca rooms
Consumer durables	• Ownership of two-wheeler
	• Ownership of washing machine
	• Ownership of television
	• Ownership of refrigerator
	• Ownership of cooker

Variables not included in the asset index

Four types of variables were eliminated:

1. Variables (such as grid electricity) that had high usage of greater than 95 per cent.
2. Those (such as ownership of laptops or computers, air conditioners, etc.) that had a low usage of less than 5 per cent.
3. Variables (like house ownership) that have economically fluctuating values.
4. Those that indicated a low correlation of less than 20 per cent variation between the top category (i.e., first) of the asset quintile and the bottom-most category (i.e., fifth) of the asset quintile.

For ease of interpretation, we rescaled this index such that the final index values range between 0 and 10. For this purpose, we used a feature scaling (or min–max scaling) formula:

$$\mathbf{Xnorm\ (or\ (IVx)) = (X - Xmin)/(Xmax - Xmin)}$$

where IVx is the normalised index value, Xmin is the initial minimum value (-3.54), and Xmax is the initial maximum value (4.61) of the asset ownership index.

16. A household with more than three members occupying a single room is considered crowded (World Health Organization 2018).

Annexure 2

Explaining the use of LPG as the exclusive fuel (simple logistic regression model)

Dependent variable: exclusive LPG use*	Odds ratio (SE)	P > z	95% confidence interval	
Asset index	1.299 (0.112)	0.002	1.097	1.540
Primary cook involved in income-generating activity	0.659 (0.202)	0.174	0.361	1.203
Female-headed households	1.399 (0.394)	0.233	0.806	2.428
Household size	0.970 (0.038)	0.446	0.898	1.048
Age of household head	0.994 (0.011)	0.583	0.973	1.016
Age of primary cook	1.003 (0.013)	0.839	0.977	1.029
Doorstep delivery of LPG cylinders	2.042 (0.508)	0.004	1.254	3.327
PMUY customer	1.011 (0.046)	0.812	0.924	1.106
Education of the primary cook (categorical; base category is education beyond the school level)				
Primary cook is not educated	0.782 (0.441)	0.663	0.259	2.361
Primary cook has a school education	1.198 (0.608)	0.722	0.443	3.240
Education of the household head (categorical; base category is education beyond the school level)				
Household head is not educated	1.377 (0.664)	0.507	0.535	3.545
Household head has a school education	1.345 (0.566)	0.482	0.589	3.070
State (categorical; base category includes households from Rajasthan)				
Uttar Pradesh	3.141 (1.103)	0.001	1.578	6.251
Bihar	1.213 (0.500)	0.639	0.541	2.720
Chhattisgarh	0.309 (0.211)	0.086	0.081	1.181
Jharkhand	1.165 (0.565)	0.753	0.450	3.014
Madhya Pradesh	1.703 (0.680)	0.182	0.779	3.723
Number of households (n) = 417				
Log likelihood = -228.777				
Prob > chi^2 = 0.000				
Pseudo R^2 = 0.126				

** The dependent variable is a dummy variable, where households using LPG exclusively are assigned a value of 1 and all other households are assigned the value of 0.*

The caste of the household has not been factored into the regression as a separate variable because of its underlying influence on economic status.

Source: Authors' analysis

Annexure 3

Air quality (PM2.5 concentration in µg/m³) across 15 districts based on CAAQMS data

Districts	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20
Gaya	79.45	61.17	62.21	63.09	45.08	40.68	31.55	62.53	109.14	121.35	96.42	58.38	41.05
Muzaffarpur	98.85	56.99	59.71	34.22	-	33.52	24.83	87.52	183.70	192.46	201.52	132.10	79.21
Patna	86.67	53.57	56.40	45.04	32.03	33.91	39.28	101.64	201.80	218.43	122.30	86.62	67.48
Bhopal	-	-	-	-	-	-	14.97	52.12	89.67	84.80	72.55	51.31	32.63
Satna	6.45	27.04	23.53	4.76	8.46	10.29	14.49	18.31	19.01	20.52	12.06	11.25	17.76
Alwar	32.92	58.94	41.43	46.52	50.63	49.72	46.23	38.04	45.77	44.85	43.54	51.13	38.50
Ajmer	45.37	57.15	61.91	47.46	34.95	26.18	27.05	55.62	58.12	50.94	45.47	50.75	40.85
Udaipur	38.81	29.31	41.43	42.92	33.24	26.91	33.13	54.41	58.35	58.20	48.12	51.18	33.59
Agra	76.91	70.54	65.39	59.23	36.91	43.14	27.34	55.82	81.54	70.45	111.37	87.94	49.72
Bulandshahr	88.64	83.92	83.47	56.61	38.72	29.41	27.60	102.24	135.00	177.01	147.45	120.22	59.42
Hapur	66.15	61.49	56.88	-	-	-	10.66	104.33	126.41	61.31	53.73	50.21	42.99
Ghaziabad	95.09	97.01	104.90	67.46	43.04	35.16	39.17	156.44	239.94	244.01	175.53	135.53	67.32
Greater Noida	83.44	82.68	73.98	53.14	39.36	27.73	32.62	128.73	208.15	215.80	162.86	116.39	54.75
Meerut	-	-	-	50.15	35.37	-	-	146.62	158.51	136.87	111.21	99.47	54.08
Noida	82.34	84.49	89.49	56.87	44.62	33.65	36.86	137.71	221.86	230.54	170.08	120.45	55.94

Source: Continuous ambient air quality monitoring station (March 2019 – March 2020)

In a rapidly urbanising India, it would be imperative for policymakers and practitioners in energy and urban development sector to integrate access to clean cooking energy within the ambit of services for the urban poor.

Image: CEEW

COUNCIL ON ENERGY, ENVIRONMENT AND WATER (CEEW)

Sanskrit Bhawan, A-10, Aruna Asaf Ali Marg
Qutab Institutional Area
New Delhi - 110 067, India
T: +91 11 4073 3300

info@ceew.in | ceew.in | @CEEWIndia