Energy for Sustainable Development 59 (2020) 151–159

Contents lists available at ScienceDirect

Energy for Sustainable Development

Household perspectives on cookstove and fuel stacking: A qualitative study in urban and rural Kenya

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ARTICLE INFO

Article history:
Received 4 May 2020
Revised 15 August 2020
Accepted 7 October 2020
Available online xxxx

Keywords:
Cookstoves
Stacking
Time use
Urban
Rural
Kenya
Mixed methods

ABSTRACT

Stove and fuel stacking is becoming accepted as part of the clean cooking transition process, even though it attenuates positive health and climate benefits that can be realized by cookstove interventions. This study analyses the underlying drivers of stove and fuel stacking from the household perspectives, and its implications for improving impact of clean cooking programs.

The study draws on a case study of two communities in Western and Northern Kenya: rural households predominantly using biomass fuels and urban households predominantly using liquefied petroleum gas for cooking. Data was collected through in-depth interviews and focus group discussions, and was analysed using the systematic procedures of grounded theory.

Stove and fuel stacking is found to be a pervasive practice, necessitated by the inability of any single cooking device to fulfill all stove applications and needs in the household. Time-costs and practical limitations associated with the primary stove, such as inability to accommodate large pot sizes were identified as the major reasons for stacking. These reasons were much more dominant than cultural attachment to traditional stoves and associated food tastes. Stacking had some highly regarded positive benefits, such as providing a fallback stove when the primary one could not meet key functionalities; and saving time by allowing for multiple dishes to be prepared simultaneously.

Our findings support other studies that have shown stacking to be a common practice, and highlights the implications of this practice for strategies aimed at scaling-out clean cookstoves.

Introduction

For three billion people globally, mostly in the low and middle-income countries (LMICs), biomass in the form of charcoal, firewood, dung and crop residues is the main source of fuel for cooking and heating (WHO, 2019). Biomass fuels are typically burnt in open fires or simple traditional stoves that do not provide optimum conditions for burning. As a result, large quantities of products of incomplete combustion including health damaging pollutants are emitted as smoke, leading to nearly 4 million deaths a year (WHO, n.d.). Biomass fuel use is also an important contributor to (WHO, 2019) emissions of greenhouse gases and short-lived climate pollutants (WHO, n.d.), deforestation and vegetation loss during fuel harvesting, and (Bhattacharya & Abdul, 2002) loss of valuable time and hardships for women and girls who gather the fuels (Bhattacharya & Abdul, 2002; Parikh, 2011; Rehman, Ahmed, Praveen, Kar, & Ramanathan, 2011).

The important role of energy access in development is recognized in SDG7 that aims to “ensure access to affordable, reliable, sustainable and modern energy for all” (McCollum, Echeverri, Riahi, & Parkinson, n.d.). Intervention measures have mainly focused on transitioning households away from traditional cookstoves and fuels to cleaner alternatives. According to the SDG 7 tracking report, progress on transitioning to modern cooking solutions is too slow, and 2.2 billion people will remain without access to modern cooking energy in 2030 (IEA et al., 2019). This concern has now led to an overall scale-up of ambition. The World Bank ESMAP for instance has recently announced a USD 500 million Clean Cooking Fund that will leverage World Bank Group and other sources of finance including private sector investments to catalyze transition to modern energy cooking services.

However, to date, even the programs that have been reported as successful have not succeeded in fully shifting households away from traditional stoves and fuels (ESMAP, 2020). Instead, households have adopted new technologies while retaining the old ones, i.e. stacking of

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https://doi.org/10.1016/j.esd.2020.10.002

stoves and fuels. In a recent systematic review (World Bank ESMAP, forthcoming) we found stove and fuel stacking to be common across nearly all cookstove programs, small and large scale, implemented across all settings. A successful LPG program in Mexico is reported to have still had almost 100% of households continuing to use firewood for cooking (Troncoso, Segurado, Aguilar, & Soares da Silva, 2019). In rural India, a large electric stove program majorly replaced LPG as a secondary fuel but did not influence a shift from traditional wood stoves as the primary cooking technology (Banerjee, Prasad, Rehman, & Gill, 2016). A longitudinal study in South Africa (Madubansi & Shackleton, 2007) found that almost a decade after introduction of electricity, over 90% of households still used fuelwood for cooking, and the mean household fuelwood consumption rates had not changed over the period. This pattern is not just witnessed in rural areas but also urban and peri-urban settings. In Indonesia, households across urban, peri-urban and rural sub-districts were found to be using LPG alongside traditional fuels after a successful fuel conversion program (Thoday, Benjamin, Gan, & Puzzolo, 2018). In Brazil where cooking fuel transition occurred in the 70s, Coelho and Goldemberg (Coelho & Goldemberg, 2013) report that LPG stoves co-exist with fuel wood stoves. The authors report a survey done in 2004 which found that 98% of urban population still owned traditional cook stoves.

Stacking behavior is often perceived in negative terms, as a hurdle to be overcome (Piedrahita et al., 2016), with very little acknowledgement of its benefits (Medina et al., 2019). WHO air quality guidelines demonstrate the need to reduce personal exposure to very low levels for the intended health benefits to be realized from cookstove interventions (Bruce et al., 2015). It is important however to consider that firstly, beyond technical stove performance, other sources of pollution in the household (e.g. from lighting, heating, rubbish burning) and neighborhood can also account for increased exposure and health risk (Saleh et al., 2020). Secondly, the impact of stacking on air quality likely depends on what stacking options are being used, and relative frequency of their use within the household. Thirdly, because most cookstove programs are designed to meet multiple objectives, it is important to separate between the implications of stacking on different program objectives, such as climate, health, gender and time-use.

Although there is a large volume of literature that demonstrate that households do not abandon their traditional cooking technologies and fuels, there are still relatively few studies on reasons why this is the case, a knowledge gap that has been highlighted by various authors (Gordon & Hyman, 2012; Medina et al., 2019; Ruiz-Mercado & Masera, 2015). While many studies report stacking to be a rationing and fallback strategy for clean fuels (Banerjee et al., 2016; Coelho & Goldemberg, 2013; Gould & Urpelainen, 2018; Jagger, Das, Handa, Nylander-French, & Yeatts, 2019; Keese, Camacho, & Chavez, 2017) whose costs are prohibitive and face supply challenges, some contexts where clean fuel is provided at highly subsidized costs and supply infrastructure is well developed are still characterized by high levels of stacking (Makonese, Kimemia, & Annegarn, 2012; Pollard et al., 2018; Thoday et al., 2018), suggesting there are multiple drivers of this practice. Similar variations are reported when it comes to stoves preferences for certain dishes, stove performance features such as cooking speed and heat control, and household characteristics such as family size as reasons for stacking (Clemens, Bailis, Nyambane, & Ndung'u, 2018; Hollada et al., 2017; Troncoso, Castillo, Masera, & Merino, 2007; Wang & Bailis, 2015). As the determinants of stacking are likely to be setting specific, studies across different settings and using a variety of methods are necessary to provide a more comprehensive picture that can guide policy and practice.

Our aim in this study is to add to the limited evidence on stacking by assessing what factors motivate it, how often secondary stoves are used, what purpose they fulfill and what implications this has for the envisaged outcomes of cookstove promotion programs. The research is timely for the Kenyan setting where a national cookstove program is being rolled out with a goal of tackling the inefficient use of biomass cooking energy. The reporting of the study follows the consolidated criteria for reporting qualitative studies (COREQ) (A, Sainsbury, & Craig, 2007; Tong, Sainsbury, & Craig, 2007).

Methods

Study setting

The study took place in Siaya Country in Western Kenya (Site 1, rural), and West Pokot County in Northern Kenya (Site 2, urban). Only 15% of Kenya's population have access to clean cooking (IEA, 2020), with the majority relying on solid biomass energy (mainly firewood and charcoal) burnt on traditional cookstoves. Of the cleaner fuel alternatives, LPG is the most predominant primary cooking fuel, followed by kerosene. Use of electricity for cooking is currently at negligible levels (0.4%) (ESMAP, 2019; GOK and CCAK, 2018).

There are stark rural and urban differences in household cooking energy choices. While less than 10% of rural households primarily use clean fuels for cooking (ESMAP, 2019; GOK and CCAK, 2018), in urban areas there is increasing use of LPG, with 41% reporting it as their primary cooking fuel, according to World Bank's national survey (ESMAP, 2019). Capturing perspectives from both rural and urban households is therefore important as tailored solutions are needed for each population segment.

In line with Sustainable Development Goal number 7 (SDG 7), Kenya has an ambitious target of achieving universal access to modern cooking solutions by 2030. The Kenya Country Action Plan for Cleaner Cookstoves and Fuels (GACC, 2013) set a target of 7 million households adopting cleaner and more efficient stoves and fuels by 2020, while the goal by 2030 is to have 35.3% of Kenya's households using LPG and another 7.6% using electricity, bioethanol and biogas for cooking by that time. The country is also implementing a national cookstove program, the Kenya Off-Grid Solar Access Project (KOSAP) with the support of the World Bank. KOSAP aims to increase access to off-grid energy, including cleaner cooking solutions in Kenya's underserved counties by supporting the creation of a sustainable market for cleaner fuels and technologies, with the goal of improving well-being of 2.5 million people (26% of underserved counties population).

The study sites were purposively selected to fulfill the requirements of this study, and generate timely and contextual knowledge to support decision making. The methods for selection of participants in each site are detailed below. In both sites, data collection occurred between January and March 2020.

Sample size

The study had no pre-determined sample size. The eventual sample for the analysis presented in this paper includes 51 participants in Site 1, and 20 participants in Site 2.

Participants

Site 1

Participants were drawn from a cohort of households that had in the past purchased an improved cookstove (ICS), through a program implemented in the community by the German Development Agency (GIZ) between 2006 and 2009. Neighboring households who did not partake in the program had been selected for comparison. The ICS had been evaluated in a prior study, and shown to reduce household air pollution, but not to significant levels that meet the WHO air quality guidelines (Ochieng, Vardoulakis, & Tonne, 2013). The stoves were however shown to significantly reduce fuel consumption, which was the main motivator for their adoption (Ochieng, Tonne, & Vardoulakis, 2013). Over 50% of the households had reported stacking the ICS with other stoves. Detailed sampling methods and characteristics of the population has been described in the previous studies (Ochieng, Tonne, & Vardoulakis, 2013; Ochieng, Vardoulakis, & Tonne, 2013). In the current study, we tracked down participants from the previous study, and those who gave consent were recruited. All households that were part of the previous study and still using ICS were eligible to participate in the current study, and half of them ($N = 51$) enrolled in the current study.

Site 2

The second study site was a geographical setting where a World Bank funded program, the Kenya Off-Grid Solar Access Project (KOSAP) is being rolled out. By design, KOSAP is being implemented in a phased approach, starting with piloting of the project's approach in four counties in the northwest of Kenya[1] (Lot 1, with a population of 2.03 million), and drawing on the lessons from this experience to expand to subsequent geographical areas. For the purposes of this study, a cluster sampling approach using non-probability techniques was employed to select West Pokot County in Lot 1 to conduct the study. The eligibility criteria for participants included (a) being a resident in the county, with residence defined as having lived there for a period of at least 6 months with no intention to move in the foreseeable future; and (b) being 15 years of age and above. There were no restrictions on gender, decision-making in the household (e.g. household head) or restriction by cooking roles performed in the household.

In both sites, the research team visited the households and administered the study information sheet that explains the purpose of the study and what it means to be a participant; and responded to any concerns raised. For those who could not read, a team member read out the information contained in the forms in the desired language of the respondent. Those who consented to being enrolled in the study were asked to sign the informed consent forms, after which a date for the interview was agreed upon. Oral consent was also permitted where preferred, and audio recorded with permission of participants.

Data collection

Data collection was through semi-structured interviews and focus group discussions (FGDs). All the study instruments were pre-tested in nearby East Pokot county to ensure that the final instruments had clarity, correspondence with the local dialect and sensitivity to cultural nuances about cooking and decision making in the study setting.

Semi-structured interviews

The semi-structured interviews were administered to individual participants. The interviews took place in participants' homes, during which time the research team was also able to observe the kitchen and cookstoves in use. The interview guide included both closed and open-ended questions. For open ended questions, participant responses were audio recorded with their consent. At the end of the interviews, select participants were invited to take part in focus group discussions (FGDs). All those who were invited to take part in FGDs consented.

Focus group discussions

The FGDs took place two weeks after individual interviews. The FGDs included 7 to 10 participants drawn from the following distinct groups: (1) those using gas as primary stove (2 groups); (2) those using improved cookstoves (ICS) as primary stove (two groups) and (3) those using traditional cookstoves as their primary stove (2 groups).

The FGDs were administered in the local languages (Luo and Pokot) by two local researchers who are familiar with the settings, and moderated by the Field Coordinator. The design of the data collection tools (FGD guides) was coordinated by the primary author who is also conversant with the local sociocultural context and language; with further input from the research advisory team. The primary author trained the local researchers on how to use the FGD guides and led the piloting of the tools. The FGDs took place in local convening venues (church and schools) that could be easily accessed by participants. Refreshments were provided to participants before commencement of the discussions, which lasted for about 1 h. Participants received a transport reimbursement of Ksh. 200 (USD 2).

All the FDGs were audio-recorded with the respondents' consent. These were complemented with notes taking on key issues that emerged during the discussions. At the end of each FGD, one of the moderators summed up the key issues discussed in the sessions as part of data validation. The moderators also sought the participants' permission to contact them at a later date in case there was need for clarification of some issues they raised or additional information requirements emerged during data analyses. All the participants consented to follow up. After each FGD, the moderators held debriefing sessions to reflect on the process, share their observations and identify ways of improving the process in the subsequent FGDs.

Data management and analysis

Data coding and analysis was carried out by the primary author. The data analysis was guided by Strauss and Corbin's grounded theory (GT) principles (Corbin & Strauss, 2014). GT is appropriate when research aims to explain a process where the concerns of those involved are central to its understanding and cannot be predetermined. Understanding the reasons why people stack cookstoves and fuels from user's own experiences without "preordained theoretical perspectives" (Gould & Urpelainen, 2018) is critical if cookstove programs are to be accepted and effective.

The core strategies of GT include recursive study design, theoretical sampling and constant comparative system of analysis (Immy, 2005; Lingard, Albert, & Levinson, 2008; Corbin & Strauss, 2016). Data analysis started with familiarization through listening to the audio tapes several times, followed by verbatim transcription of each interview and FGD audio tape. The transcripts were then re-read repeatedly, noting down any points that stood out from the initial readings. The transcripts were then subjected to open coding by assigning descriptor statements to text that presented particular meanings. This was done for each of the interview and FGD transcripts; and then compared across the transcripts and field notes. This was followed by grouping together of all the data that represented similar meanings - thereby breaking down the data and reassembling it together through constant comparison of transcripts and notes to tease out underlying meanings. Emerging themes were identified by grouping together similar concepts represented by the generated codes. The themes were then checked to see if they corresponded with the extracted data linked to the codes attached to them, and also if they fitted the entire data from the transcripts and the notes. After retrieving all the emerging themes, they were then redefined and renamed to develop clear story lines from the data. For the present paper, the emerging theme of stacking is explored.

In grounded theory, data collection and analysis are non-distinct process, and theoretical sampling should continue to data saturation point. However at the time of writing this paper, some themes had not been fully explored due to COVID-19 crisis and social distancing rules that made if unfeasible to follow-up on some findings and hold feedback sessions with participants. Instead the emergent themes and related issues were compared with the findings from other studies reported in literature to check for similarities and differences. It is worth noting that not all GT studies result in substantive theories, and data saturation is not reached in many studies due to time and other practical limitations.

Results

Characteristics of respondents

Table 1 below summarizes the characteristics of participants in the two study sites, and illustrates some stark differences between the

[1] West Pokot, Turkana, Samburu, Isiolo and Marsabit Counties.

Table 1
Socio-demographic profiles of participants.

Variables	Site 1 ($n = 51$)	Site 2 ($n = 20$)
Age (Mean, sd)	49 (14.3)	25.1 (17.3)
Years of schooling	6.2 (3.1)	12.8 (5.5)
Main source of income		
Farming	77%	–
Salaried employment	2%	42%
Informal/self-employment	15%	47%
Other	6%	11%
Family size	5.0 (2.7)	4.3 (2.2)
Marital status		
Married	67%	56%
Widowed	31%	9%
Single	3%	35%
Main house floor type		
Mud	67%	–
Cement or other	33%	100%
Respondent is primary cook		
Yes	88%	56.6%
No	12%	43.4%
Length of stay in current dwelling	5.8 (6.6)	1.9 (1.6)

two categories of participants. In comparison to Site 1 participants (rural), urban respondents tended to be younger and better educated, and with more regular sources of income. The characteristics are reflective of the sampling design of the study rather than the general population characteristics. In site 1 participants included those who had participated in a previous stove evaluation program and therefore of higher age group. In site 2 participants were purposively sampled based on the use of LPG as a primary cookstove, which is associated with higher socio-economic status.

Biomass as the primary cooking fuel for most households

In Site 1 most participants (94.5%) reported firewood as their primary cooking fuel. In contrast none of participants in Site 2 reported use of firewood as either primary or secondary fuel.

Nearly all participants stack cookstoves, but the primary stove remains dominant

Nearly all participants had one stove they considered to be the primary stove. Stove stacking was reported by 83.1% of participants, although even amongst this group the primary stove remained dominant, with respondents reporting its usage on a daily basis. Apart from the main stove, 84.5% of respondents had one secondary stove, 13.8% had two secondary stoves and 1.7% had three or more secondary stoves.

Stacking combinations exist along a continuum from dirty stacking to clean stacking stove portfolios

Table 2 below shows the main categories of stacking that emerged during the study. Categories that are missing from the table were not prevalent amongst the participants. There were no primary LPG users who stacked with firewood, and use of kerosene or electric stoves (as either primary or secondary stove) was negligible. We also did not find significant stacking with residues, possibly because the study was conducted outside the harvest seasons. The majority of those who owned ICS had the fixed version. Potable versions were also in use, but not as primary cookstoves. Most of the ICS had two burners, although there were many reported incidences of one of the burners having been blocked or damaged and therefore no longer in use. With the exception of ICS, all other cookstoves, including LPG stoves had single burners. Amongst the few participants that did not stack (16.9%), 8 of them reported having an extra stove of the same design, which was only used occasionally.

Table 2
Typologies of stove and fuel stacking.

	Cooking stove combinations	
	Primary stove	Secondary stove
DS2	ICS	3-stones stove
DS3	LPG	Charcoal stove (traditional or improved)
CS1	3-stone stove or ICS	LPG
CS2	3-stone stove or ICS	Charcoal stove
CS3	3-stone stove or ICS	Kerosene
CS4	Charcoal stove	LPG

Note: DS, Dirty Stacking; CS, clean stacking. ICS – either fixed or potable, with one or double burners. CS connotes an upward movement toward cleaner cooking, not that the fuel involved (e.g. charcoal or kerosene) meets the internationally accepted standards of cleanliness.

Main reasons for stove and fuel stacking

Three main reasons were identified in relation to choices made to stack the primary stove with other cookstoves across the groups: i) time saving from parallel cooking; ii) inability of primary cookstove to cook all dishes; iii) housing arrangements that preclude use of certain fuel types and iv) fuel availability and cost. Several factors were categorized under these themes, including family composition, weather conditions, level of personal organization and cleanliness. Many examples from participants identified past or ongoing experience of cooking with only one stove, which they found to be highly undesirable or impossible, leading to stacking of stoves and fuels.

i) Time savings are a key driver of stove stacking

The need to save time spent in preparing meals was a fundamental reason for stacking for all category of participants, including those who were exclusive users of traditional cookstoves. The process of preparing one dish at a time was perceived in very negative terms, as time consuming, and with multiple implications. Cooking one dish at a time was a more recurrent reason for stacking compared to the speed at which the stove would cook. The responses below show how much emphasis is put on time saving as a reason for stacking:

> "*It is possible to use my (primary) stove for all my cooking, if I have time available. If not I need multiple stoves. Because it takes time to cook one food item, remove, cook another remove, cook another …*"
>
> [- DS2]

> "*I spend a lot of my time cooking (with one burner stove). I have to first boil vegetables, fry and set it aside; then make the stew; then ugali (maize meal), then boil milk. But if I have multiple stoves I can cook ugali and vegetables in parallel*"
>
> [- DS2]

Participants provided very elaborate reasons on why they would not wish to spend a lot of time cooking. The pressure was often tied to fixed schedules for school and work. Thus, for some participants who had no school-going children, or during periods of school closure and weekends, they reported no need for stacking. For urban residents, lateness for work was a primary concern.

> "*I cannot use one stove for all my cooking, it just can't work. Many a time I am in a rush. I have to prepare meals in time for my school-going children who need to do their homework after supper and sleep early … my husband wants his meals ready on time … my past experience of using only one (burner) stove was very stressful and I would not go back to it*"
>
> [- DS3]

"*I can cook on one stove when am not in a hurry. But when am in a rush, such as after coming back late from the market, even in the past when I only had a three stone stove, I would put another set of three stones, otherwise my children would sleep hungry. Even now I have an improved stove but when am in a rush I light the three-stone stove or jiko* (*charcoal stove*)"

[- DS2/CS2]

"*I use both gas and jiko* (*charcoal stove*) *for cooking. In the mornings I use gas, but during the day and evening when there is no rush to get children ready for school I use jiko. Also when am just home and not going anywhere I use jiko*"

[- CS4]

Others reported only needing extra stoves when they had guests, which was occasional. When there were no guests the extra stove was not put to use.

However, even in some instances when there was no pressure to have the food ready in time, the time it takes to cook one dish after another was still perceived negatively.

"[*Experience of preparing meals on one stove*] … *Is very difficult. You must wait for vegetables to cook, fry it, then prepare ugali, then make tea. I spend several hours sitting by the stove*"

[- 3-stone stove user, not stacking]

"*In the past, over 10 years ago, I had only one stove. It was a very difficult time. You cook one item, put it down, cook another. I like this stove because it allows me to cook two items simultaneously and I do not spend a lot of time sitting in the kitchen cooking.*"

[– ICS user, not stacking]

"*I do not like slow things. Having one stove* (*burner*) *slows me down. I want ugali and vegetables to cook together* (*in parallel*)"

[– ICS, not stacking]

For a few respondents however, spending a long duration of time cooking was not viewed as a concern, even though it still emerges implicitly as an important attribute of the cooking experience. Others saw it as an attribute they could control; through self-organization rather than by acquiring another stove.

"*I cook all my meals on one stove. The experience is not bad at all. I make the stew, set it aside, wash the pot, cook something else. When am done I make tea, make porridge for my child, everything … am used to it*"

[- 3-stone stove user, not stacking]

"*I do not mind at all cooking on one stove, but I must start early. If I start late it will delay me, I must then light a second stove*"

[– CS2]

"*I can cook on one stove without any problems, because I plan ahead. I am well-organized. If the meal is to be eaten at 7 pm I start at 3 pm. I ensure I have properly dried wood. When the wood is dry the stove cooks at the right pace for me*"

[- 3-stone stove user, not stacking]

Those with ICS were less likely to stack than those with 3 stone stoves, as the ICS stoves had double burners. One recurring narrative from this category of participants was having "…*no reason to stack*…" implying that simultaneous cooking was possibly the most appreciated attribute of ICS. There were reported occasions where the second burner did not work, or dry split wood required for the stove was unavailable. Under these circumstances, participants reported stacking or reverting to 3-stone stoves.

Time saving as an important reason for stacking is supported by interviews with participants who did not stack but also reported time savings as a primary reason for having the additional stove.

"*Having just one stove really slows down cooking. When I have several stoves, then two or more of us can cook at the same time. One person is cooking ugali while the other is preparing the stew*"

[- Multiple 3-stone stoves user, not stacking]

ii) Inability of primary cookstove to perform all functions

The aspects that emerged strongly and more consistently were the practical limitations of certain stove types for certain functions; that would be resolved by stacking with another cookstove. For instance, it was not practical to use large cooking pots on small-size stoves. The need for large-size pots arose when guests were present; when the stove was needed for heating bath water or boiling water for drinking; making tea for a large size family; or for meals made in bulk to be consumed over several days such as *githeri* (a mixture of boiled dry corn and beans). The challenge of preparing githeri in non-traditional cookstoves was very dominant, due to limitations of size, as well as high fuel consumption which was also perceived as a practical limitation.

Githeri is a Kenyan staple consumed by nearly all the 40 ethnic groups across Kenya. The meal is a mixture of dried corn mixed and legumes (often beans). In many households githeri is prepared at least twice a week. Because of its high energy intensity, it is frequently prepared in bulk (not daily), thus requiring large size pots. Preparation of this meal was reported to almost always require use of secondary stoves, except for households that relied on three-stone stoves, as exemplified in the following statements.

"*Githeri takes eight hours to cook. You may need 4 cylinders of gas in a month if you use it for githeri. I can't imagine myself preparing githeri on gas*"

[– CS4]

"… *Yes, charcoal is more expensive than gas but one tin of charcoal, costing Ksh. 20, can cook githeri and is ready to serve. But if you open gas consistently for one hour the content of the cylinder will all be consumed*!"

[– CS4]

"*When I purchased my stove, the builders asked me to show them the pots I regularly use for cooking. They then measured the stove using these pots. I can therefore cook everything on this stove, except for githeri. For that I must go back to 3-stone stove*"

[– DS2]

"*I do not face any difficulties with this stove regardless of the meal am preparing. The only time I face difficulty is in preparation of githeri. The pot does not fit on the stove*"

[– DS2]

Very few participants with non-traditional cookstoves observed that they could prepare githeri on those stoves.

iii) Type of housing and tenancy impacts on stove stacking

Type of housing was a recurrent theme for stacking but highly dependent on the context and socio-economic status. Most of the rural participants had their kitchens as a separate building that is not attached to the main house. Meals prepared in those kitchens would be transported to the main house for consumption. The inconvenience of moving meals from the kitchen to main house especially during rainy seasons led to switching of cooking location to the main house for participants who could afford this option. Aside from the weather, arriving back home late would also motivate cooking in the main house. This switch would entail changing to a cleaner cookstove: LPG or charcoal stove that would not dirty the main house. Although ICS was also viewed as clean enough to be used in the main house, most households had the stoves fixed in their kitchens and not portable. For participants with portable ICS, they noted the ability to switch cooking location to the main house when necessary as one of the benefits of having those stoves.

Unlike the rural areas, housing arrangements in urban areas was a dominant theme influencing the choice of secondary stoves. The urban housing units do not include separate kitchen locations where wood could be burned for cooking, thereby eliminating wood stoves as a cooking option in those settings. Participants reported that stacking with kerosene stoves was not an option either because of its smell. Electricity could not be used as primary or secondary fuel because of cost, unreliability and a general lack of perception that it can be a form of energy for cooking. For many participants, they were hearing for the first time through questions posed by the interviewers that electricity is considered as a cooking energy. The secondary stove option was therefore LPG for those using charcoal as primary fuel, and charcoal for those whose primary fuel was LPG.

iv) Fuel availability and cost is a dominant factor for urban stove users

While fuel availability was a category under the three themes presented above, it emerged as a dominant factor amongst the urban residents. For this group the cost of the fuel also featured strongly as a reason for stacking, and the type of energy to stack with. The stacking was always with charcoal (DS3).

"*Here in Keringet there is no assurance with gas, that if it is finished today you will find it. The supply is very unreliable. The way we get it is we leave an empty cylinder, get receipt, they re-fill and you pick it the next day … and it will not always be there. So I use charcoal in the meantime.*"

"*When the gas is finished it can take a week before the next supply becomes available. That is why I have two options. My first option is gas, but when there is no gas I use charcoal.*"

The challenge of gas availability was coupled by the fact that it could run out without warning.

"*At times gas is finished and I do not have Ksh. 1000 at the time, I need a day or two before I can get the money. So I use charcoal.*"

"*Normally I just get surprised that the gas is finished, at times in the middle of cooking. That is why I always have a debe (large tin) of charcoal stocked for emergency.*"

A few respondents reported using gas exclusively, having developed other coping measures for its unavailability. This included owning two cylinders. One participant, who lived on his own, reported eating in a hotel when he ran out of gas, which for others was not an option.

You see, the scenario P1 describes (of eating in a hotel) can only work because he lives alone. Me I have children I cannot take them to eat in a hotel. Those of us with children we have no choice but to use other fuels for cooking.

A few participants reported they did not experience challenges in obtaining gas when they needed it and for that reason, would not stack with other fuel.

I use gas exclusively. No other (fuel) options. If it is finished I run to the station to fill it, even if it is night. For now it is readily available.

Rural household perspectives on fuel availability and stacking centered only around the energy dense meal of githeri, with some reporting that they would not waste their "good wood" (split wood) on githeri, and others reporting they would not use charcoal to prepare githeri because it would be too expensive.

v) Taste and other food preferences are not major drivers of stacking

Although a recurrent category under the themes, food taste did not emerge as a key consideration in the decisions to stack, and had less convergence of the narratives. There were divergent perspectives on what type of stoves would be suitable for preparing certain dishes, with some contradicting views as well. Additionally, there were divergent views on attributes of the cookstoves such as cooking speed, tending requirements and fuel efficiency - that would determine their suitability for preparing certain dishes.

While others preferred slow cooked beans and would switch from wood stove to charcoal on this account, others wanted it to cook fast and would therefore switch from ICS (which had slower heat transfer) to three-stone stove that cooked faster. The variation in narratives was particularly prominent amongst ICS users, where strong individual preferences and perceptions about the stoves became apparent. Some participants observed that they could cook chapati on ICS, while others contradicted this, observing that ICS could not be used to make chapati.

"*I am at times compelled to purchase charcoal if I want to make beans. Because this allows it to cook very slowly, giving it a very nice taste…. Instead of 3 stone fire that goes (makes fast burning sounds) where you pile wood on all sides and it cooks very fast, and the beans do not turn out as I would like*"

[- *CS2*]

"*This stove (ICS) cooks very fast and therefore not suitable for stews that need to simmer for long periods for them to come out well. Therefore when making stews I use charcoal. For foods that I want to cook fast such as beans I use the ICS*"

[– *CS2*]

"*I do not use my stove (ICS) for all meals. Not for warming vegetables, making chapatis or rice. For warming food I use three-stone stove because it goes fast; rocket is suitable for slow cooking such as beef and fish stew. For Chapati and rice I use jiko*"

[– ICS user, stacking with multiple stoves]

Even for a meal like githeri where there was consensus amongst other stove users, the views were divergent in the ICS group.

For some participants, most of them in the ICS group, the primary stove was meeting all their cooking needs:

"*I cook everything on this one stove. They made it for me with two burners; very convenient. Whether it is ugali, stew, githeri … it cooks githeri in just 2 hours. Even roasting beef (for preservation) I use the same stove. I just leave it on top of the stove covered overnight, and it dries from the heat retained by the stove after cooking; in the morning I find it dry. All my meals are prepared on this stove*"

[– ICS user, not stacking]

"*Before I got this stove I would mix different stoves but not after this one …. Each one had its limitations. Jiko is very slow … 3-stone wastes a lot of heat … after I got this stove I no longer needed any other stove. It cooks everything I need … I no longer have the 3-stones*"

[– ICS user, not stacking]

In contrast, most participants who used three-stone stoves to prepare all their meals did not report satisfaction with the stoves; often citing factors such as ash getting in the food and making it dirty therefore unsuitable for stews, or the food acquiring the taste of smoke. Stacking would occur when one needed to prepare a special family meal, or preparing meals for guests. In such situations, charcoal stoves would be used mainly for stews, rice and chapati.

Relative value attached to certain fuels

The perspective of value being attached to certain fuels – which in turn influences what food items they can be used to prepare – was constant but could not be exhausted due to study interruption. For instance, even though LPG was observed to be cheaper than charcoal by many participants, and was one of the reasons for using it as a primary fuel, participants would not use LPG for githeri and other high energy intensity dishes because it would finish the gas. For the same reason, some participants only used LPG for breakfast. Similarly, in rural areas, even though the ICS was preferred because it used less fuel, using it to prepare githeri was considered a waste of the good split wood. In rural areas some households had gas cylinders that lasted more than 3 months (on average a cylinder lasts a month for a single-family household) because it was being preserved. Because this factor is also correlated with stove suitability and fuel availability, it is not possible to draw conclusions on its influence on stove adoption without further investigation.

Discussion

This qualitative study assessed the reasons for cookstove and fuel stacking based on user's experiences, given the widely reported pervasiveness of this practice, which can greatly hamper the ability of cookstove programs to achieve their end goals of reduced health risks from pollution or climate impacts. Our findings support those of several other studies that have shown cookstove and fuel stacking is the norm, with just 17% of respondents reporting exclusive use of one stove type or fuel. We find that secondary stoves serve important basic functions without which the households would experience difficulties and “stress”. Of these functions, time savings through simultaneous cooking, and overcoming practical limitations of primary cookstoves were dominant and left the participants with “no choice” but to stack.

While the participants noted strong preferences of certain stove types for certain dishes, this was a less dominant reason for stacking. The preferences varied considerably, and were at times contradictory. Designing a cookstove that responds to all these variations of individual taste and preferences, which are also transient in nature, would be an uphill task. On the other hand, designing a cookstove that addresses the commonly shared practical challenge of having to cook one dish at a time, having a stove that can accommodate large pots, and fuel availability and price can be tackled through unified refocused efforts.

Our findings illustrate various benefits of stacking; with implications that it should not always be perceived in negative terms as reflected by programs that target removal of traditional cookstoves either in the short or long term. This view is shared by other authors (Dickinson et al., 2019; Medina et al., 2019; Ruiz-Mercado & Masera, 2015; Shankar et al., 2020) who have argued that rather than targeting replacement of traditional cookstoves, programs should acknowledge the reality of stacking and promote instead a suite of clean stacking options. By stacking different stoves, women were able to save time and cook their meals on time, with important implications for the overall welfare of the family including children's education.

As expected, the 3-stone stove was the most common primary cookstove in rural areas. Any stacking in these regions should therefore imply an improvement in indoor air quality, because it is the benchmark for polluting cookstoves. Unlike rural areas, stacking in urban areas was a mix of both clean and dirty stacking, involving two fuel types: LPG and charcoal. Stacking was a necessity for overcoming supply, cost and practical challenges of relying on LPG (as earlier noted, using LPG to cook *githeri* was considered impractical). In urban households, the separation of primary and secondary stove was not distinct, even though LPG clearly emerged as the most preferred stove. This was a common finding with rural areas as well; whereby the transition technology (ICS) was preferred, and use of 3-stone stove perceived by some participants as “going back” due to lack of choice.

Given the positive benefits of stacking we have found, and the fact that no single fuel and technology is currently able to meet all household requirements as observed in many other settings, stacking designs and strategies should be part of cleaner stove promotion efforts. Making this an explicit goal would allow for design and promotion of cooking solutions that can only target these secondary functions, and target them well. Many of the secondary functions performed by traditional stoves could be substituted with more efficient appliances, for instance pressure cookers that could prepare *githeri* in short time, water heaters and boilers that can be powered by grid or off-grid electricity amongst a range of other solutions.

Other practical solutions could include standardization of number of burners of cookstoves to more than one as potential solution to the recurrent narrative of resorting to traditional stove to enable simultaneous preparation of dishes. Demonstrations that show parallel dishes being prepared on a stove can be part of marketing strategies for clean cookstoves.

Further research

Educational impact of primary reliance on traditional cookstoves came out strongly but could not be probed further in the current study. The focus thus far has been on the time girls spend fetching wood (WHO, 2019). Other aspects such as delayed meals add another important dimension to consider. As this issue would affect both girls and boys, it could offer a gender-neutral entry point and help in engaging men more on issues of clean cooking, given their strong role in household purchase decisions (Miller & Mobarak, 2013).

Additional studies that focus on cleaner stacking as the primary outcome of interest are needed. Often stacking is considered in post-hoc analysis to help explain why certain cookstove did not perform in indoor air pollution or health improvements, the primary goal of most evaluations. By studying cookstove stacking behavior and the role of secondary stoves in particular, rich insights can be obtained on user needs that can inform design of interventions, leading to better success in stove and fuel adoption. A category not exhausted in this study but of high policy relevance is the role of stacking in enabling households to sample cleaner cooking alternatives and contributing to learning that can support intra-household energy transitions to cleaner cooking.

More studies are also needed on cookstove transitions in urban settings, which to date remain poorly understood (ESMAP, 2020), and are often not targeted by stove promotion efforts. We found housing arrangements in urban areas to be a dominant factor influencing fuel choice in these settings. Stacking with highly polluting fuels such as firewood and kerosene was eliminated by default by the type of tenancy (not through a stove intervention program). Urban households can therefore be prime targets for achieving an exclusive switch to cleaner stoves and fuels, as there is only one competing fuel option which is charcoal, and its use is by necessity (not preference). Additional studies are needed to support these findings to be able to influence sector strategy.

A further research gap is longitudinal assessments that measure the change in stove use patterns within households; particularly how long the cleaner stoves and fuels remain as the primary cooking options. This would allow for identification of negative transition trends and factors that could be responsible for them, and focusing intervention efforts on these. There is also a need to characterize exposure by distinguishing between those who stack and those who do not stack, thereby allowing for 3 categories of cookstove users (traditional, mixed and clean) and design of solutions that target their unique needs. For instance, we find that even in rural areas, there is high level of stacking with charcoal stoves, which suggests the need to promote efficient charcoal stoves in these regions. This information is lost when the population is given one label of traditional stove users. Our findings therefore support the move toward national surveys that take into account multi-dimensionality of energy access, such as ESMAP's Multi-Tier Framework Surveys (Energy Sector Management Assistance Program (ESMAP), 2020) that collect information on both the primary and secondary cookstoves.

Finally, some interesting emergent themes could not be exhausted, for instance on relative value attached to certain fuels. The practice of reserving LPG for certain cooking tasks such as breakfast preparation, warming food, and for preparation of special meals has been observed in other settings (Velasco, n.d.; Álvarez, Palma, & Tay, 2004; Barnes, Kumar, & Openshaw, 2012; Troncoso et al., 2019; Wang & Bailis, 2015). Our study appear to suggest that beyond cost and challenges associated with refilling LPG, there could be other underlying factors that drive the practice, that would warrant further investigation.

The findings of this study should be interpreted with some caution, taking into account practical limitations such as sample size, inability to achieve data saturation, and context specificity of qualitative studies that limits the ability to generalize the findings. Our study does however have key strengths. To our knowledge it is the first study in the setting to focus on cookstove stacking as a primary outcome, and to utilize an interpretive approach. The results generated are applicable to the context of a national cookstove program in Kenya financed by the World Bank who are likely to apply the findings based on collaborations established during design of the study.

Conclusions

Cookstove and fuel stacking is the norm, not the exception; although of a lesser concern to the sector's development than is currently perceived. On the contrary, we posit that stacking is an essential component of the pathway of transition to cleaner cookstoves and fuels, which will be a gradual process rather than a step change (given several bottlenecks that are accompanied with the newly adopted cooking technologies and fuels). Households that stack are actually on a clean cooking energy transition pathway, which should be perceived as a positive outcome. Stacking enables trial and error adoption of different cookstoves and fuels by end-users, allowing tailored stacking strategies to be developed as a form of user-driven innovation. Thus, stacking should be actively promoted amongst those who have not yet begun this clean cooking transition process. The intervention measures should entail offering a cleaner cooking option for adding to the existing traditional one as opposed to trying to completely replace it. The increasing penetration of electricity offers an opportunity for addressing some of the challenges that lead to stacking, but also, more importantly, options for addressing the highly negative experiences of exclusive reliance on traditional stoves.

For those in the transition pathway who have not yet reached the end goal, retaining them on the clean cooking transition pathway should be as equally important as trying to move them upward to exclusive use of clean stoves and fuels. There is a high risk of this group going down the 'primary energy ladder', where the cleaner options become secondary and the traditional ones occupy the primary place. Promoting coping measures, such as making a second gas cylinder available at lower cost for those having one, and standardizing cookstoves to two burners, are some practical solutions that could be used to reduce dependence on polluting alternatives.

Future research and surveys should pay equal attention to secondary cookstoves within cleaner stacking strategies. With study designs and measurements that focus only on primary cookstoves, the role of the secondary stoves is diminished even though they offer very important value to the households, and form a core part of the cleaner cooking transition process.

Abbreviations

ICS	Improved cookstoves
LPG	Liquefied Petroleum Gas
LMIC	Low and middle-income country
ESMAP	Energy Sector Management Assistance Program
SUM	Stove Use Monitor
COREQ	Consolidated Criteria for Reporting Qualitative Studies
SDG	Sustainable Development Goal
KOSAP	Kenya Off-grid Solar Access Project
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
FGD	Focus Group Discussion
DS	Dirty Stacking
CS	Clean Stacking

Ethics approval and consent to participate

The study received ethical clearance from National University of Ireland Galway Ethics Committee, and Strathmore University Ethics Committee (Reference Number SU-IERC0551/19). The identity of the participants have been anonymized to ensure confidentiality.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request.

Funding

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 713279, administered through Irish Research Council Collaborative Research Fellowships for a Responsive and Innovative Europe (CAROLINE; Project ID: CLNE/2018/522). Additional financing has been provided by the World Bank Energy Sector Management Assistance Programme (ESMAP).

CRediT authorship contribution statement

CAO designed the study and methods, supervised the collection of data, analysed the data and wrote the manuscript. JKN and DIA facilitated data collection, transcriptions and supported with preliminary coding and quantitative analyses. YZ in her capacity as secondment mentor guided in the design of the research questions to ensure their policy relevance, as well as facilitating links with World Bank country program in Kenya and providing critical review to the research methods. CS provided guidance on the research methods and ethics approval, critical review of data analysis and review and edits of the final manuscript. All authors of the manuscript have read and agreed to its content.

Declaration of competing interest

The study has been conducted while CAO was on secondment to ESMAP and contributing to implementation of clean cooking programs at the World Bank. ESMAP co-financed data collection in Kenya.

All authors declare no competing interests. ESMAP and the World Bank had no role in the analyses or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

Acknowledgements

We are grateful to all participants who took time off their busy schedules to contribute their perspectives. We acknowledge the support of World Bank ESMAP in hosting the fellowship under which the proposed research is based, and the World Bank KOSAP task team. We also extend our gratitude the following individuals who provided guidance on the research methods and/or analyses: Dr. John Owuor

(Stockholm University), Dr. Una Murray (Nua Consulting, Ireland) and Dr. Debbi Stanistreet (Royal College of Surgeons in Ireland).

References

A, Sainsbury, P., & Craig, J. (2007). Consolidated criteria for reporting qualitative research (COREQ): A 32–item checklist for interviews and focus groups. *International Journal for Quality in Healthcare*, *19*, 349–357.

Álvarez D, Palma C, Tay M. Evaluation of improved stove programs in Guatemala: Final report of project case studies December 2004. 200.

Banerjee, M., Prasad, R., Rehman, I. H., & Gill, B. (2016 Jan 1). Induction stoves as an option for clean cooking in rural India. *Energy Policy*, *88*, 159–167.

Barnes D, Kumar P, Openshaw K. Cleaner hearths, better homes: New stoves for India and the developing world. 2012.

Bhattacharya, S. C., & Abdul, Salam P. (2002 Apr 1). Low greenhouse gas biomass options for cooking in the developing countries. *Biomass and Bioenergy*, *22*(4), 305–317.

Bruce, N., Pope, D., Rehfuess, E., Balakrishnan, K., Adair-Rohani, H., & Dora, C. (2015 Apr 1). WHO indoor air quality guidelines on household fuel combustion: Strategy implications of new evidence on interventions and exposure–risk functions. *Atmospheric Environment*, *106*, 451–457.

Clemens, H., Bailis, R., Nyambane, A., & Ndung'u, V. (2018 Oct 1). Africa Biogas Partnership Program: A review of clean cooking implementation through market development in East Africa. *Energy for Sustainable Development*, *46*, 23–31.

Coelho, S. T., & Goldemberg, J. (2013 Oct 1). Energy access: Lessons learned in Brazil and perspectives for replication in other developing countries. *Energy Policy*, *61*, 1088–1096.

Corbin, J., & Strauss, A. (2014). *Basics of qualitative research: Techniques and procedures for developing grounded theory.* Sage publications.

Corbin, J., & Strauss, A. (2016). Grounded theory research: Procedures, canons and evaluative criteria. *Z Für Soziol.*, *19*(6), 418–427.

Dickinson K, Piedrahita R, Coffey ER, Kanyomse E, Alirigia R, Molnar T, et al. Adoption of improved biomass stoves and stove/fuel stacking in the REACCTING intervention study in Northern Ghana. 2019.

ESMAP. ESMAP (2019). Kenya national multi-tier framework. Energy Access Household Energy Survey K.

Energy Sector Management Assistance Program (ESMAP) (2020). *The State of Access to Modern Energy Cooking Services.* Washington, DC: World Bank.

ESMAP (2020). *Analysis of the drivers and barriers for transition to modern energy cooking services (MECS): A systematic evaluation of the evidence.* World Bank (in press).

GACC (2013). Kenya country action plan. https://www.cleancookingalliance.org/binary-data/RESOURCE/file/000/000/236-1.pdf.

GOK and CCAK (2018). Kenya household cooking sector study: Assessment of the supply and demand of cooking solutions at the household level.

Gordon, J., & Hyman, J. (2012 May 21). The stoves are also stacked: Evaluating the energy ladder, cookstove swap-out programs, and social adoption preferences in the cookstove literature. *Journal of Environmental Investing.*, *3*(1), 17–41.

Gould, C. F., & Urpelainen, J. (2018 Nov 1). LPG as a clean cooking fuel: Adoption, use, and impact in rural India. *Energy Policy*, *122*, 395–408.

Hollada, J., Williams, K. N., Miele, C. H., Danz, D., Harvey, S. A., & Checkley, W. (2017). Perceptions of improved biomass and liquefied petroleum gas stoves in Puno, Peru: Implications for promoting sustained and exclusive adoption of clean cooking technologies. *Int J Environ Res Public Health.*, *13*, 14(2).

IEA. IEA 2020. Africa energy outlook: Kenya https://www.iea.org/articles/kenya-energy-outlook.

IEA, IRENA, UNSD, WB, & WHO (2019). *Tracking SDG 7: The energy progress report 2019, Washington DC.*

Immy H. Qualitative research in health care. McGraw-Hill Education (UK); 2005. (321 p).

Jagger, P., Das, I., Handa, S., Nylander-French, L. A., & Yeatts, K. B. (2019 Mar 1). Early adoption of an improved household energy system in urban Rwanda. *EcoHealth.*, *16* (1), 7–20.

Keese, J., Camacho, A., & Chavez, A. (2017 Jan 2). Follow-up study of improved cookstoves in the Cuzco region of Peru. *Development in Practice*, *27*, 26–36.

Lingard, L., Albert, M., & Levinson, W. (2008 Aug 7). Grounded theory, mixed methods, and action research. *BMJ.*, *337*, a567.

Madubansi, M., & Shackleton, C. M. (2007 Jun). Changes in fuelwood use and selection following electrification in the Bushbuckridge lowveld, South Africa. *J Environ Manage.*, *83*(4), 416–426.

Makonese, T., Kimemia, D., & Annegarn, H. (2012). Assessment of free basic electricity and use of pre-paid meters in South Africa. *Proceedings of the 20th Conference on the Domestic Use of Energyx.* IEEE (pp. 165–172).

McCollum D, Echeverri LG, Riahi K, Parkinson S. Access to affordable, reliable and sustainable modern energy for all. 47.

Medina, P., Berrueta, V., Cinco, L., Ruiz-García, V., Edwards, R., Olaya, B., et al. (2019 Nov). Understanding household energy transitions: From evaluating single cookstoves to "clean stacking" alternatives. *Atmosphere.*, *10*(11), 693.

Miller G, Mobarak AM. Gender differences in preferences, intra-household externalities, and low demand for improved cookstoves [Internet]. National Bureau of Economic Research; 2013 Apr [cited 2019 Nov 18]. Report No.: 18964. Retrieved from http://www.nber.org/papers/w18964.

Ochieng, C. A., Tonne, C., & Vardoulakis, S. (2013 Nov 1). A comparison of fuel use between a low cost, improved wood stove and traditional three-stone stove in rural Kenya. *Biomass and Bioenergy*, *58*, 258–266.

Ochieng, C. A., Vardoulakis, S., & Tonne, C. (2013). Are rocket mud stoves associated with lower indoor carbon monoxide and personal exposure in rural Kenya? *Indoor Air*, *23* (1), 14–24.

Parikh, J. (2011 Dec 1). Hardships and health impacts on women due to traditional cooking fuels: A case study of Himachal Pradesh. *India. Energy Policy.*, *39*(12), 7587–7594.

Piedrahita, R., Dickinson, K., Kanyomse, E., Coffey, E., Alirigia, R., Hagar, Y., et al. (2016 Oct 1). Assessment of cookstove stacking in Northern Ghana using surveys and stove use monitors. *Energy for Sustainable Development*, *34*, 67–76.

Pollard, S. L., Williams, K. N., O'Brien, C. J., Winiker, A., Puzzolo, E., Kephart, J. L., et al. (2018 Oct 1). An evaluation of the Fondo de Inclusión Social Energético program to promote access to liquefied petroleum gas in Peru. *Energy for Sustainable Development*, *46*, 82–93.

Rehman, I. H., Ahmed, T., Praveen, P. S., Kar, A., & Ramanathan, V. (2011 Apr). Black carbon emissions from biomass and fossil fuels in rural India. *Atmospheric Chemistry & Physics Discussions.*, *1*, 11(4).

Ruiz-Mercado, I., & Masera, O. (2015 Feb). Patterns of stove use in the context of fuel–device stacking: Rationale and implications. *EcoHealth.*, *28*, 12.

Saleh S, Shepherd W, Jewell C, Lam NL, Balmes J, Bates MN, et al. Air pollution interventions and respiratory health: a systematic review [Internet]. 2020 [cited 2020 May 4]. Retrieved from https://www.ingentaconnect.com/content/iuatld/ijtld/2020/00000024/00000002/art00002.

Shankar, A. V., Quinn, A. K., Dickinson, K. L., Williams, K. N., Masera, O., Charron, D., et al. (2020 Jun 1). Everybody stacks: Lessons from household energy case studies to inform design principles for clean energy transitions. *Energy Policy*, *141*, 111468.

Thoday, K., Benjamin, P., Gan, M., & Puzzolo, E. (2018 Oct 1). The Mega Conversion Program from kerosene to LPG in Indonesia: Lessons learned and recommendations for future clean cooking energy expansion. *Energy for Sustainable Development*, *46*, 71–81.

Tong, A., Sainsbury, P., & Craig, J. (2007 Dec 1). Consolidated criteria for reporting qualitative research (COREQ): A 32-item checklist for interviews and focus groups. *International Journal for Quality in Health Care*, *19*(6), 349–357.

Troncoso, K., Castillo, A., Masera, O., & Merino, L. (2007 May 1). Social perceptions about a technological innovation for fuelwood cooking: Case study in rural Mexico. *Energy Policy*, *35*(5), 2799–2810.

Troncoso, K., Segurado, P., Aguilar, M., & Soares da Silva, A. (2019 Oct 1). Adoption of LPG for cooking in two rural communities of Chiapas, Mexico. *Energy Policy*, *133*, 110925.

Velasco I. More sustainable cooking technologies – A case study in rural kitchens in Michoacan, Mexico. 49.

Wang, Y., & Bailis, R. (2015 Aug 1). The revolution from the kitchen: Social processes of the removal of traditional cookstoves in Himachal Pradesh, India. *Energy Sustain Dev.*, *27*, 127–136.

WHO | Burning opportunity: Clean household energy for health, sustainable development, and wellbeing of women and children [Internet]. WHO. [cited 2019 Jan 10]. Retrieved from http://www.who.int/airpollution/publications/burning-opportunities/en/.

WHO. Global Health Observatory (GHO) data. https://www.who.int/gho/phe/indoor_air_pollution/burden/en/.