Health Perceptions of Smart Meter Liquefied Petroleum Gas Users in Nairobi's Informal Settlement

Willah Nabukwangwa[1*], Margaret Nyongesa[2] and Mohamed Karama[3]

[1]Kenya Medical Research Institute (KEMRI), Nairobi, Kenya; [2]Amref International University, and [3]Umma University

***Corresponding author**: Willah Nabukwangwa. Email address: willahnabu@gmail.com

DOI: https://dx.doi.org/10.4314/ajhs.v36i3.8

Abstract

INTRODUCTION

Household air pollution (HAP) from cooking with polluting fuels increases the risk of developing respiratory diseases. The use of a smart-meter liquefied petroleum gas (LPG); Pay-as-you-go (PAYG) model that eliminates cost barriers may increase the use of LPG, reduce HAP exposure, and lower the burden of respiratory diseases. Lack of awareness of the effects of HAP is a barrier to the exclusive use of LPG. This cross-sectional study examined smart meter users' awareness of air quality and perception of health risks associated with HAP among PAYG customers in Mukuru informal settlement, Nairobi Kenya.

MATERIALS AND METHODS

The study targeted household customers who have been cooking with PAYG LPG for at least two years. Surveys (n=330) and focus group discussions (FGDs) (n=32) participants were selected using multistage and purposive sampling techniques respectively. Quantitative and qualitative data were descriptively and thematically analyzed using STATA and NVIVO respectively.

RESULTS

The majority, who cooked with no separate kitchen room 147(60%) were worried about kitchen smoke (p-value=0.038). Also, 129(65%) of those who used smart meter LPG with other polluting fuels (p-value =0.021), and most 79(63%) who had experienced respiratory symptoms were concerned about kitchen smoke (p-value<0.05). Results further revealed participants' overall low awareness of indoor/outdoor pollution and little concern about respiratory health risks associated with HAP, due to a focus on more immediate issues, like; food security. The motivation to use LPG was more linked to economic considerations than health benefits.

CONCLUSION/RECOMMENDATION

Results highlighted the potential for the smart-meter LPG (PAYG) model for exclusive adoption of LPG especially in the informal settlement and recommended the need to create awareness of the negative effects of HAP.

***Keywords**: HAP, PAYG, Respiratory Diseases and LPG Adoption.*

[***Afr. J.** Health Sci*. 2023 36 (3): [254-264]

Introduction

More than half of the world's population and a majority of sub-Saharan African (SSA) countries use polluting fuels such as wood, charcoal, and kerosene for cooking in poorly ventilated homes, resulting in household air pollution (HAP) [1]. Exposure to HAP leads to more than 4 million premature deaths each year, including 23,000 in Kenya due to respiratory diseases such as childhood pneumonia, low birth weight, asthma and cardiovascular diseases [2], deaths more deaths than malaria, tuberculosis and HIV combined [3]. Women and children are disproportionately affected due to exposure during cooking, time spent cooking, and fuel collection, leading to

missed economic and educational opportunities [4]. HAP also harms the climate through black carbon emissions and the environment from unsustainable wood extraction.

Although the hazardous effects of HAP can be mitigated by anyone in the community [5], it is usually overlooked because of limited awareness and its invisibility except at very high concentrations [6]. The World Health Organization (WHO) recommends the use of liquefied petroleum gas (LPG) as the most cost-effective solution to promote sustainable, clean cooking that can reverse the negative health and environmental impacts of HAP [7] and help achieve the United Nations Sustainable Development Goals (SDGs) for health - SDG 3 and global access to clean, modern and affordable energy - SDG 7, by 2030 [7]. However, the exclusive use of LPG for cooking is far from being realized [8], as cooking is complex, and associated with welfare reasons such as cost barriers, and social preferences like its possibility of cooking traditional foods [9], but often neglecting important aspects such as health and the environment [10]. Recently, the Kenyan government proposed that households should switch to clean LPG by 2025 for health and environmental benefits [11]. Thus, making the use of LPG a public health and national policy priority.

Efforts have been made globally and in Kenya to promote the sustainable adoption of LPG, including improved energy-efficient cooking pots and LPG microfinance [12,13]. More recently, smart LPG technology has been introduced under the pay-as-you-go (PAYG) model, which allows incremental payment of gas and helps customers track LPG consumption in real time (grams), which frees users from access barriers [14]. However, the exclusive use of LPG among the population is still low [8] due to inadequate environmental health awareness which forms an early warning signal from the community needed to make a change and reduce community hazards [15] and can lead to positive health outcomes on environmental related diseases [16]. One vulnerable population is people living in informal settlements who experience energy poverty [8] and generally have a poor perception of air pollution [15] since understanding is usually influenced by the immediate environment, *"People associate positively with their immediate environment"*. Social construction is crucial [17] for contextualizing awareness of air quality which can link determinants for sustainable adoption of clean cooking fuels and reduce exposure to HAP.

This study, therefore, aimed to explore the awareness of smart meter LPG users on respiratory health risks associated with HAP. The results will contribute to the wider literature on the sustainable use of LPG and potential solutions to reduce HAP by suggesting determinants of LPG adoption beyond cost.

Materials and Methods

Study location

The study was conducted in the Mukuru informal settlement in Nairobi Kenya. Mukuru is the second largest informal settlement with eight villages located on an estimated 647 acres of land in Embakasi South Constituency in Nairobi County [18]. It was purposively selected because of its rapid growth and potential for the upsurge of respiratory health risks among residents [19] and the dominance of PAYG customers. (Fig 1).

Study design

A cross-sectional study design, adopting a mixed-method approach was used. Data were collected between October and November 2022.

Sample size and sampling

The study included participants from the 2,000 active customers in the PAYG company database at the time of the survey. Fisher's formula ($n = z^2 \times p \times (1-p)/d2$) was used to obtain a sample size of 384 considering a 95% confidence level ($z = 1.96$) and a prevalence of 50%. The sample size was corrected to adjust for small populations (less than 10,000) as: nf= n/(1+n/N); n = 384, and N = 2,000 (20), plus an additional 10% (30); 330 to cater for non-response and dropouts.

A multi-stage sampling technique was used to determine survey participants. First, villages were selected using a systematic sampling approach, then households were selected using a random approach.

A total of 32 participants were purposely selected to collect qualitative data, considering age distribution, gender and LPG consumption.

Data collection

The survey targeted household consumers; either primary or household heads, with more than two years, using smart-meter LPG (PAYG) and aged 18 years and above.

Quantitative data was collected using questionnaires and qualitative data was obtained using Focused Group Discussions (FDGs)

Tools were validated by environmental health experts and piloted. These results were triangulated to validate and contextualize the results.

Data analysis and management

Quantitative data was cleaned and analyzed using STATA 14. Frequencies and chi-square were used to determine the significance of the data. The audio-recorded qualitative interviews were transcribed and translated into English, before being exported into QSR NVivo 12 for data analysis.

A thematic framework approach was adopted to classify and organise data into themes using an iterative analysis process and analysis charts prepared for each theme and category of participants.

Ethical consideration

Research approval was obtained from the AMREF Ethics and Scientific Review Committee (ESRC P1274-2022), and the National Commission of Science, Technology, and Innovation (NACOSTI/P/22/21394), offered a permit to conduct the study. Additionally, written informed consent was obtained from each participant before collecting data.

Results

Socio-demographic, kitchen and cooking characteristics

More than two-thirds (69%) of respondents were female, 80% were primary cooks, and 20% were household heads. Respondents' mean age was 38 years (SD: 10), while the mean and SD for the household members was 4.1 (SD: 1.6).

The majority (79%) of smart meter LPG users were married. Almost one-quarter (24%) of study participants either had no formal education or completed primary school. More than one-third (44%) earned a salary of less than 20,000 Kenyan Shillings (Kshs).

Figure 1:
A section of Mukuru informal settlement in Nairobi, Kenya.(Source: EPA/Dai Kurakawa)

The average amount of smart meter LPG used by participating households was 1.04 (kg)/capita/month (SD=0.80); the minimum and maximum amounts were 0.02 and 6.3 (kg)/capita/month, respectively. Three-quarters of the households (74%) didn't have a separate kitchen room, and therefore, cooked within the main household; the remaining households either had a separate kitchen room (74%) or cooked from outside the main house (6%).

Nearly half (48%) of the participants reported using smart meter LPG exclusively (100%; according to their self-reported weekly time cooking with polluting fuels) and consumption data. (Table 1).

Table 1:
Socio-economic and Kitchen characteristics among pay-as-you-go LPG users in Mukuru Informal settlement, Nairobi Kenya in October 2022

Variables	n=330	n (%)
Gender		
Female	229	(69.4)
Male	101	(30.6)
Age (Mean, SD)	38.1, 9.6	
Respondent house role		
Household head	66	(20.0)
Main cook	264	(80.0)
Number of household members (Mean, SD)	4.1, 1.6	
Number of children under 5		
None	185	(56.1)
More than 1	145	(43.9)
Education level		
Not completed/ completed primary level	78	(23.6)
Completed Secondary	172	(52.1)
Tertiary (University, College)	80	(24.2)
Range Salary Income		
20,000 and below	145	(43.9)
More than 20,000	63	(19.1)
Don't Know / Won't disclose	122	(37.0)
Marital Status		
Married	261	(79.1)
Unmarried	69	(20.9)
Amount PAYGO LPG Used (kg/capita/month)	1.04, 0.80	
Per cent of cooking with PAYG LPG		
0-50%	128	(41.4)
51-99%	51	(16.5)
Exclusively PAYG LPG (100%)	147	(47.6)
Kitchen Characteristics		
Indoors, No separate Kitchen room	243	(73.6)
Indoors in a separate kitchen room	66	(20.0)
Open doors, no defined kitchen room	21	(6.4)
Kitchen ventilation		
Window and/or chimney	284	(91.9)
Neither Window and/nor chimney	25	(8.1)

Amount PAYGo LPG: Amount of LPG in kg/capita/month used by PAYGO smart meter LPG users
Per cent of cooking done with PAYG LPG is a derived variable based on the number of hours participants self-reported using each cooking fuel type every week and consumption data
SD: Standard deviation

General community understanding of air quality

More than half (53%) and almost all (94%) smart meter LPG customers perceived their outdoor and indoor environments to be clean, respectively. Only 1% of participants reported that the air quality in their kitchen was dirty; slightly more (13.9%) believed that the outdoor air was dirty, (figure 2).

Findings from the FGDs confirmed a low awareness of air pollution, with mixed perceptions about the air quality in their community. Most perceptions were sensory and informed by sight and odour. Smelly drainage channels, emissions from industries, garbage waste, and toilets were pointed as major outdoor sources of pollution while using polluting fuels was highlighted as a source of household air pollution, as cited:

"R2: It is emitted from the things we use, charcoal burning, toilets, and garbage disposal which needs better disposal." - (*FGD-3 Men Decision Makers*)

Also, when asked about the awareness of hazards between outdoors and indoors, participants did not have a clear opinion as to which environment posed the most danger. Their general belief on the hazards of air pollution was based on the number of people they perceived were affected by air pollution sources, and their ability to regulate emissions.

Most participants found outdoor air pollution to be more problematic than household air pollution due to its visibility and consistent exposure.

Participants also conveyed a state of helplessness related to living in a slum, with little ability to improve existing air quality conditions, stating "*What shall we do*?" suggesting that they were resigned to their fate of living in a polluted environment. As attributed by a decision maker;

"R3: It's because you can control household air pollution by reducing the consumption of different fuels and all that, but outdoors different people are contributing to the air pollution with their vehicles, others are dumping litter all over, the wrong disposal of waste and fumes from industries that cannot be controlled." (FGD-3 Men Decision Makers)

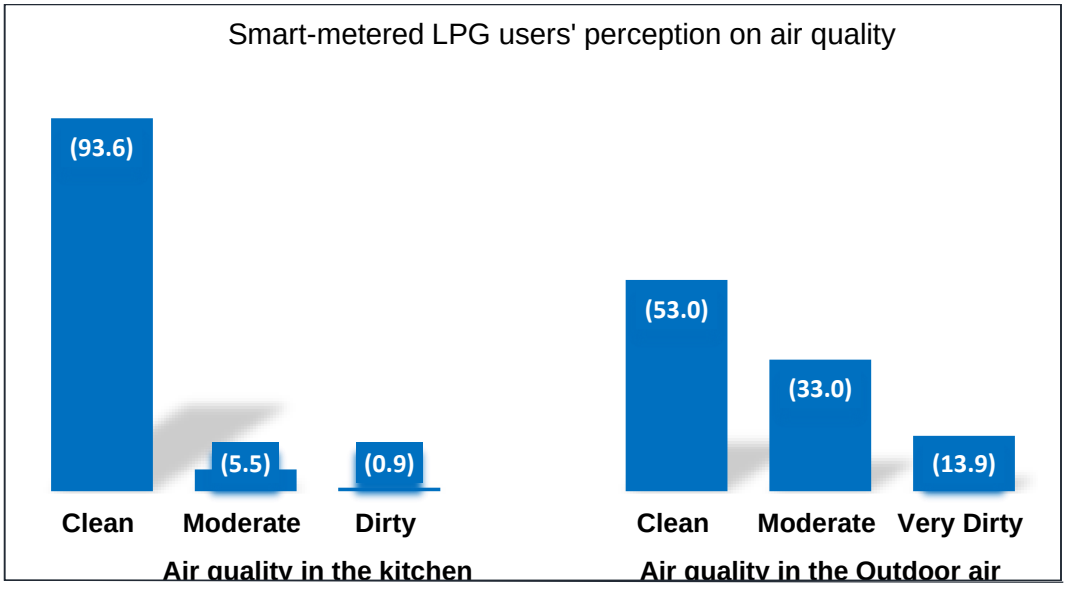

Figure 2:
Perception of air quality among smart meter LPG household users in Mukuru Informal settlement, Nairobi Kenya in October 2022

Other participants identified household air pollution as more hazardous than outdoor pollution due to a more concentrated exposure and the type of housing material. Some participants expressed, though indistinctly, awareness of the health effects of household air pollution from previous personal or community experience; the commonly highlighted source of HAP was polluting fuels used for cooking such as charcoal and firewood, conducted in either poorly ventilated or houses that lacked ventilation. As mentioned,

"R5: The effects of household air pollution are worse than outdoor air pollution as there might be no aeration which causes adverse health effects. When charcoal is not burnt wholly it causes suffocation and loss of energy to people in the house." (FGD 3 Men Decision Makers)

Awareness of health risks associated with exposure to cooking smoke

More women than men were worried about the harm of kitchen smoke however the proportions didn't differ significantly. Those who cooked outside with no structured kitchen and those who didn't have a separate kitchen structure (71% and 60%) respectively were significantly worried about kitchen smoke compared to those who had separate kitchens (40%) (p-value = 0.038). Also, participants who exclusively cooked with LPG were more worried about the health effects of cooking smoke (33%) than those stacking smart meter LPG with polluting fuels (67%) (p-value =0.021). Three in every five households (63%) of participants who had experienced at least one respiratory symptom were significantly concerned about kitchen smoke compared to those who had not experienced any respiratory symptoms. (Table 2).

Health risk associated with cooking smoke was vaguely described after random probes to tease out responses. Respondents linked the vicinity of smoke from cooking fuels to the poor health effects of air pollution. Other respondents mentioned that the nearness of the source of fuel caused near-immediate health effects, such as breathing difficulties, eye irritation or feeling of burning/ irritation in the throat, headaches, and convulsions. There was no difference in perception among men or women as well as decision and non-decision makers. The perception was largely influenced by personal experiences:

"R5: Persistent flu on me and my children and convulsions on my child one time… I did take into the house a jiko that was not well-lit then my daughter convulsed and fainted. We took her outside and then she regained her conscience." (*FGD-002 Women Decision-Makers*)

"I stopped using jiko because it gives me headaches, dizziness, and chest congestion." (*FGD-001 Men Non-Decision Makers*)

According to a few participants, HAP-associated effects were not a major concern. Participants mentioned the presence of other competing needs, which lessened the attention they provided to smoke pollution as a major health threat. The participants stated that poverty, which resulted in a lack of basic needs, distracted them from their concern about the smoke from cooking polluting fuels. As articulated:

"People living in poverty, you cannot talk about pollution around them as they have gone without food and lack shelter, so finding firewood for them is like it becomes a challenge to ask them" (FGD-001 Men Non-Decision)

"R2: Poverty affects you psychologically, you must accept your state despite disliking the environment around you knowing very well you cannot get yourself out of it." (FGD-001 Men Non-Decision-Maker)

Participants recognized the health benefits of cooking with cleaner fuels like LPG, anticipating reduced air pollution. They also believed that the smart metered PAYG system for LPG could promote sustained usage due to its flexible payment and easy accessibility. They emphasized the importance of government support for promoting smart meter

LPG to enhance widespread access. Additionally, they called for government subsidies on LPG prices to ensure affordability for a larger user base:

"R5: There are companies like PAYGo and M-gas that are issuing out gas at an affordable rate, so we would request the government to fund them, so they can cover a bigger scope like the rural areas and other places. so that ordinary Kenyans can access gas" (FGD-004 Women Non-Decision Makers).

Table 2:
Bivariate analysis of select characteristics and worry of harm from smoke from cooking fuel in Mukuru Informal settlement in Nairobi, Kenya in October 2022

	Worried		Moderately Concerned		Not concerned		Total	P-value (χ2 test)
Variables	n=192	(%)	n=62	(%)	n=76	(%)	N=330	
Age								
Below 35	74	(56.5)	26	(19.8)	31	(23.7)	131	0.872
35 and Above	118	(59.3)	36	(18.1)	45	(22.6)	199	
Gender								
Male	54	(53.5)	23	(22.8)	24	(23.8)	101	0.402
Female	138	(60.3)	39	(17.0)	52	(22.7)	229	
No. of Children > 5								
None	108	(58.4)	33	(17.8)	44	(23.8)	185	0.857
One or More	84	(57.9)	29	(20.0)	32	(22.1)	145	
Education Level								
No Education	47	(60.3)	13	(16.7)	18	(23.1)	78	
Completed Secondary	100	(58.5)	38	(22.2)	34	(19.9)	171	0.302
Tertiary level	45	(56.3)	11	(13.8)	24	(30.0)	80	
Rooms in Household								
Single rooms	75	(56.8)	28	(21.2)	29	(22.0)	132	
2 Rooms	71	(58.7)	21	(17.4)	29	(24.0)	121	0.926
3 or More Rooms	46	(59.7)	13	(16.9)	18	(23.4)	77	
Marital Status								
Unmarried	36	(52.2)	15	(21.7)	18	(26.1)	69	
Married	156	(59.8)	47	(18.0)	58	(22.2)	261	0.522
Kitchen Location								
Indoors, No separate Kitchen room	147	(60.5)	48	(19.8)	48	(19.8)	243	
Indoors in a separate kitchen room	30	(45.5)	12	(18.2)	24	(36.4)	66	0.038
Open doors, no defined kitchen room	15	(71.4)	2	(9.5)	3	(14.3)	21	
Kitchen Ventilation								
Neither	17	(68.0)	7	(28.0)	1	(4.0)	25	
Window and Chimney	160	(56.3)	53	(18.7)	71	(25.0)	284	0.052
Stackers								
Yes	129	(65.1)	40	(17.5)	60	(26.2)	229	
No	63	(53.3)	22	(22.7)	12	(12.4)	97	0.021
Experienced respiratory symptom								
Yes	79	(63.2)	32	(25.6)	14	(11.2)	125	<0.001
No	113	(55.1)	30	(14.6)	62	(30.4)	205	

Further, they acknowledged the poor perception among community members on linking the health effects to air pollution, and thus pointed to the need to ensure the community is empowered on hazards of HAP:

"R2: There should be education and empowerment among people on the risks of other fuel types and the advantages of gas (*FGD-003 Men Decision-Makers*)

Discussion

From this study, participants' overall concern, knowledge, and awareness of respiratory health risks associated with HAP was relatively low and intertwined with different factors. Results showed the potential of using smart meter technology through incremental payment (flexible payment modality) as a possible solution for cost barriers and sustainable use of LPG [10,14], for promoting health and reducing other negative health impacts associated with HAP. If this technology is widely adopted by companies and awareness of the negative effects of HAP exposure is created[20].

Overall, most of the study participants were female and mainly cooked in households without having a separate kitchen. Previous research has shown that women are the main cooks [4], and a lack of a separate cooking room is aligned to poor socioeconomic status, as people in informal settlements cook in the same room where they sleep [20]. The majority used smart-meter LPG along with other polluting fuels. Similar findings have shown that communities mostly stack (use polluting fuels alongside clean fuels) to meet their daily cooking demand, majorly due to cost and time constraints [9].

Most participants perceived their air quality in the kitchen as clean or moderate. A previous study on perceptions of air quality showed that people tend to associate positively with their environment (*halo-effect*) since they are used to it [15]. Perception of pollution was formed by senses (sight and smell) also, most community members were not certain which environment posed the greatest health risk. Similar results have shown low levels of knowledge among communities who believed that emissions from factories and general outdoor air pollution as harmful to health, as opposed to HAP [15]. Findings highlight the vulnerability of people living in informal settlements who cannot attribute to the effects of air pollution based on their other needs [10].

Participants without kitchen ventilation and non-exclusive LPG users were significantly more likely to be concerned and report potential health risks associated with cooking smoke. Also, those who had at least one respiratory symptom were worried about the of kitchen smoke on health, suggesting that those who suffered from respiratory symptoms may have had a heightened awareness of the potential harmfulness of smoke. A significant number of participants who had previously had negative experiences with HAP switched to using LPG as a mitigating strategy for the health benefits, particularly due to its convenient payment modality that involved incremental payment of LPG. Results suggested that the use of PAYG LPG is a potentially sustainable solution due to the economic benefits that can increase the population's access to LPG if the government further subsidizes the cost. This finding is consistent with other research that found understanding the health risks posed by HAP serves as an important warning sign and is associated with an increase in community positive action to reduce exposure [15,21]. In addition, the novelty knowledge of the negative effects of HAP from cooking fuels can influence a quicker switch to LPG given the affordability and accessibility of alternative sources [21].

The results of the study show a certain level of ignorance, which can be explained by a lack of environmental and health education. Also, there was an apparent lack of agency as people felt powerless to reduce pollution in their communities; the helplessness of the residents and a lack of agency can be elucidated by their low social status, the poor environment they are exposed to, and the limited opportunities available to them. The findings,

therefore, highlight the importance of environmental health education, in addition to the reduction of financial burden and consideration of flexible LPG payment models, such as the PAYG, as a solution to enhance the sustainable use of LPG. An obvious way to engage and raise community awareness is by using health workers who play a positive role in compliance, uptake, and dissemination of information.

Strengths and Limitations

Our study was cross-sectional using self-reported data, which may have led to social desirability bias, however, data were triangulated to ensure validity and to minimize bias, also the research assistants were trained to be as objective as possible. Moreover, the use of accurate measurement of LPG usage among participants was a key strength in data collection, to understand and contextualize usage and perception of risk associated with HAP among users. Additionally, research assistants were locals who used Kiswahili while collecting data to minimize misunderstandings with the respondents.

Conclusion and Recommendations

Results suggested that smart meter LPG technology together with increased awareness can be a potential sustainable solution to promoting public health in vulnerable communities. A significant knowledge gap regarding the association between HAP and health highlights the need for behavioural change to mitigate the threat of HAP, including exclusive use of LPG.

Therefore, there is a need for multi-sectoral collaboration between the ministries of health and energy to lobby for tax relief on LPG gas. The government could play a significant role in creating an enabling environment that includes supportive tax/importation policies and fuel price control measures that can improve health associated with the risk of HAP. LPG investors could also support new market ventures through the adoption of the PAYG LPG model, considering the positive findings about the consumer value proposition of accessibility and affordability through their flexible payment modes through this research. Also, there is a need for educational programs that can increase awareness about the negative effects of HAP in the local community. This approach may help increase communities' motivation to reduce their collective HAP exposure. Without these measures, achieving UN SDG; 7; access to clean energy Goal 3; and promoting health by 2028 may be unrealistic.

Author contributions

The authors were involved in the conception, study design, interpretation, and development manuscript. Willah additionally carried out the analysis and trained research assistants.

Author contact emails

1. Willah Nabukwangwa - willahanbu@gmail.com
2. Margaret Nyongesa- maggwande@gmail.com
3. Mohamed Karama- mhmdkarama20@gmail.com

Acknowledgments

We are grateful to Amref University staff members for their support during the study, the research assistants for their incredible job of collecting data, and the study participants for their time and cooperation.

Conflicts of Interest

No conflict of interest was declared by the authors.

References

1. **Quinn AK, Williams KN, Thompson LM, *et al.*** Fidelity and Adherence to a Liquefied Petroleum Gas Stove and Fuel Intervention during Gestation: The Multi-Country Household Air Pollution Intervention Network (HAPIN) Randomized Controlled Trial. *Int J Environ Res Public Health* 2021;18(23):12592; doi: 10.3390/ijerph182312592.
2. **World Health Organization.** WHO Guidelines for Indoor Air Quality: Household Fuel Combustion. *World Health Organization:* Geneva; 2014.
3. **Landrigan PJ, Fuller R, Acosta NJR, *et al.*** The Lancet Commission on pollution

and health. *The Lancet* 2018;391(10119):462–512; doi: 10.1016/S0140-6736(17)32345-0.

4. **Jagoe K, Rossanese M, Charron D, *et al*.** Sharing the burden: Shifts in family time use, agency and gender dynamics after introduction of new cookstoves in rural Kenya. *Energy Res Soc Sci* 2020;64:101413; doi: 10.1016/j.erss.2019.101413.
5. **Kotouzas,Stamatis.** Concept Project Information Document-Integrated Safeguards Data Sheet. Text/HTML. 2019. Available from: https://documents.worldbank.org/en/publication/documents-reports/documentdetail/500301511794282642/Concept-Project-Information-Document-Integrated-Safeguards-Data-Sheet [Last accessed: 5/10/2023].
6. **Wong-Parodi G, Dias MB, Taylor M.** Effect of Using an Indoor Air Quality Sensor on Perceptions of and Behaviors Toward Air Pollution (Pittsburgh Empowerment Library Study): Online Survey and Interviews. *JMIR MHealth UHealth* 2018;6(3):e8273; doi: 10.2196/mhealth.8273.
7. **International Energy Agency, International Renewable Energy Agency, United Nations, *et al*.** Tracking SDG7: The Energy Progress Report 2018. *World Bank*, Washington, DC; 2018.; doi: 10.1596/29812.
8. **Shupler M, Pope D, Puzzolo E, *et al*.** COP26 and SDG7 Goals under Threat: 16% VAT on LPG Reverses Progress Made in Clean Cooking Adoption in Kenya. 2022.; doi: 10.13140/RG.2.2.15161.85603.
9. **Ochieng C, Zhang Y, Nyabwa J, *et al*.** Household perspectives on cookstove and fuel stacking: A qualitative study in urban and rural Kenya. *Energy Sustain Dev* 2020;59:151–159; doi: **10.1016/j.esd.2020.10.002.**
10. **Martin SL, Arney JK, Mueller LM, *et al*.** Using Formative Research to Design a Behavior Change Strategy to Increase the Use of Improved Cookstoves in Peri-Urban Kampala, Uganda. *Int J Environ Res Public Health* 2013;10(12):6920–6938; doi: 10.3390/ijerph10126920.
11. **Anonymous.** President Ruto Directs All Public Institutions to Transition to LPG by 2025 » Capital News. n.d. Available from: https://www.capitalfm.co.ke/news/2023/02/president-ruto-directs-public-institutions-schools-households-to-transition-to-lpg-by-2025/ [Last accessed: 5/10/2023].
12. **Nabukwangwa W, Clayton S, Mwitari J, *et al*.** Adoption of innovative energy efficiency pots to enhance sustained use of clean cooking with gas in resource-poor households in Kenya: Perceptions from participants of a randomized controlled trial. *Energy Sustain Dev* 2023;72:243–251; doi: 10.1016/j.esd.2022.12.010.
13. **Puzzolo E, Zerriffi H, Carter E, *et al*.** Supply Considerations for Scaling Up Clean Cooking Fuels for Household Energy in Low- and Middle-Income Countries. *GeoHealth* 2019;3(12):370–390; doi: 10.1029/2019GH000208.
14. **Shupler M, Mangeni J, Tawiah T, *et al*.** Modelling of supply and demand-side determinants of liquefied petroleum gas consumption in peri-urban Cameroon, Ghana and Kenya. *Nat Energy* 2021;6(12):1198–1210; doi: 10.1038/s41560-021-00933-3.
15. **Egondi T, Kyobutungi C, Ng N, *et al*.** Community Perceptions of Air Pollution and Related Health Risks in Nairobi Slums. *Int J Environ Res Public Health* 2013;10(10):4851–4868; doi: 10.3390/ijerph10104851.
16. **Orru K, Nordin S, Harzia H, *et al*.** The role of perceived air pollution and health risk perception in health symptoms and disease: a population-based study combined with modelled levels of PM10. *Int Arch Occup Environ Health* 2018;91(5):581–589; doi: 10.1007/s00420-018-1303-x.
17. **Bickerstaff K, Walker G.** Public understandings of air pollution: the 'localisation' of environmental risk. *Glob Environ Change* 2001;11(2):133–145; doi: 10.1016/S0959-3780(00)00063-7.

18. **Kim H-S, Yoon Y, Mutinda M**. Secure land tenure for urban slum-dwellers: A conjoint experiment in Kenya. *Habitat Int* 2019;93:102048; doi: 10.1016/j.habitatint.2019.102048.
19. **Greibe Andersen J, Karekezi C, Ali Z, *et al*.** Perspectives of Local Community Leaders, Health Care Workers, Volunteers, Policy Makers and Academia on Climate Change Related Health Risks in Mukuru Informal Settlement in Nairobi, Kenya—A Qualitative Study. *Int J Environ Res Public Health* 2021;18(22):12241; doi: 10.3390/ijerph182212241.
20. **Edelstein M, Pitchforth E, Asres G, *et al***. Awareness of health effects of cooking smoke among women in the Gondar Region of Ethiopia: a pilot survey. *BMC Int Health Hum Rights* 2008;8(1):10; doi: 10.1186/1472-698X-8-10.
21. **Macherera M, Chimbari MJ**. A review of studies on community based early warning systems. *Jàmbá J Disaster Risk Stud* 2016;8(1):206; doi: 10.4102/jamba.v8i1.206.