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Did COVID-19 Change the Availability and Use of Clean Energy for Cooking? Evidence From Ghana

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ABSTRACT: A major part of Ghana's current household energy policy is focused on using a branded cylinder recirculation model (BCRM) to promote the safe use of Liquefied Petroleum Gas (LPG) for primary cooking. The implementation of the BCRM is expected to increase LPG adoption by households to the announced policy goal of 50% of the population by 2030. We investigated the impact of the COVID-19 pandemic on the implementation of the BCRM, availability, and household use of cleaner fuels. This was assessed using existing data on clean fuel use prior to the COVID-19 pandemic. Additional data was collected using questionnaire-based household surveys and qualitative interviews. It was found that the expansion of BCRM was significantly impacted by the COVID-19 pandemic. Planning activities such as baseline data collection and stakeholder engagement were delayed due to the COVID-19 restrictions. Changes in household incomes during the pandemic had the biggest percentage effect on household choice of cooking fuel, causing a regression in some cases, to polluting fuel use. This study provides insights that could be valuable in future understanding of the interactions between pandemic control measures and economic disruptions that may affect household energy choices for cooking.

KEYWORDS: Charcoal, liquefied petroleum gas, Ghana, income, COVID-19, cylinder recirculation model

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Introduction

The outbreak of the COVID-19 pandemic and the measures to contain the infection have devastated health systems and economies across the world.[1-3] Household income has been affected by the cessation of the informal economy[4,5] directly impacting households' ability to afford clean energy (especially where there is available biomass for gathering). These disruptive changes are likely to sway households into the use of polluting fuels for cooking—especially in the context of resource-poor countries, which likely operate under the energy ladder model (where households transition from polluting fuels to less polluting ones, following improvements in economic status).[6] Studies have shown that use of polluting fuels such as firewood and charcoal burnt in simple cookstoves increases personal exposure to household air pollution, resulting in debilitating effects.[7-9] The greatest health burden from residential cooking-related emissions is linked to exposure to fine particulate matter (PM2.5) and carbon monoxide (CO), which remains very high mainly among developing countries,[10,11] causing 3.2 premature million deaths each year.[12]

In Ghana, the majority of households in rural communities use biomass fuels for cooking while about 51.3% of those in urban areas use liquified petroleum gas (LPG) for primary cooking.[13] The Government of Ghana has since 1989 implemented policies to reduce reliance on biomass fuels for cooking, including the 2013 Rural LPG program and the 2017 National LPG promotion policy.[14] The latter policy is to be achieved through the transition to a branded cylinder recirculation model (BCRM) to promote safe use of LPG for household energy and increase LPG adoption by households to the announced policy goal of 50% of the population by 2030.[15] Unlike the current LPG market structure operating in Ghana ("cylinder owned model"), the BCRM shifts the responsibility of ownership and maintenance of cylinders to LPG marketers and facilitates market expansion through exchange of pre-filled cylinders sold by authorized retail points.[16]

Ghana reported its first cases of COVID-19 infections on 12th March 2020. This was immediately followed by the introduction of containment measures including nationwide closure of schools, band on public gatherings, physical distancing, and travel bands. Yet, by April 21, barely a month after the outbreak, confirmed cases had risen rapidly reaching a total of

* Co-first authors.

1042 infections including 9 deaths.[17] Realizing that most of all confirmed cases and deaths were reported from the 2 most populous regions—Greater Accra and Ashanti, the latter being 1 of our 2 study areas, a 3-week partial lockdown was introduced to limit viral transmission in these areas. Unlike the Kintampo study site, Obuasi was one of the hardest hit by COVID-19 and was considered a high-impact area.[18] Before the outbreak, the National Petroleum Authority (NPA) was piloting a transition to the BCRM in the Obuasi Municipality, which was investigated by the CLEAN Air (Africa) Global Health Research Group.[19] While no incentives were introduced to encourage household consumption of LPG during the pandemic, the Government of Ghana provided free electricity for lifeline users (defined as households who use less than 50 kW per month) and a 50% reduction in electricity prices for households who use more than 50 kW per month.[20] This paper reports the findings of a study that assessed the effect of the COVID-19 pandemic on the availability and use of clean cooking fuels (LPG and electricity) in Ghana. The study also assessed the effect of the pandemic on the planned implementation of the BCRM in one of the pilot areas (Obuasi).

Materials and Methods

Study design

We implemented a cross-sectional study that employed a mixed-method approach covering household surveys, key informant qualitative interviews, and a stakeholders' workshop discussion. The Exploration, Preparation, Implementation and Sustainment (EPIS) implementation framework[21] was used to guide the study (Figure 1). The framework also aided a focused assessment of the impact of the COVID-19 pandemic on the different phases of the BCRM implementation led by Ghanaian authorities. The usefulness of the EPIS framework in guiding similar evaluation studies has been articulated in previous research.[22]

Study setting

The study was conducted in the Kintampo-North and Obuasi Municipalities of Ghana (referred to as Kintampo and Obuasi respectively). Kintampo-North is in the Bono East Region of Ghana and has a population of 156 145 with an average household size of 4.9 persons.[23] The municipality serves as a transition zone between the arid Northern and wetter Southern parts of Ghana. At the beginning of the pandemic in Ghana and at the start of the study, Kintampo was experiencing a low prevalence of COVID-19. Obuasi Municipality is located in the South-Western part of the Ashanti Region. It has a population of 168 641 and the average household size is 4.0 persons.[24] Obuasi is known for its mining activities. This area was also a site for the national pilot of the BCRM, implemented by the NPA.

Sampling and participant recruitment

Our target study population for the quantitative survey was 400 primary LPG users in each of the 2 study sites. The sample was informed by assuming a 40% prevalence of LPG users in the study area (based on our earlier study in Obuasi where 40% of the 2000 households are LPG users),[23] a 95% confidence interval, which resulted in a sample of 370 households to detect a difference of 5%. Adjusting for a 8% non-response rate gave an overall sample of 400.

Participants were sampled from the Kintampo Health Demographic Surveillance System's database and from the Obuasi CLEAN-Air (Africa) baseline household survey (n = 2000).[19] Of these 2 study areas, Kintampo is largely rural and Obuasi is peri-urban. Residency in the study areas and reporting use of at least 1 clean energy for cooking in the recent past or during the baseline CLEAN-Air (Africa) survey for Obuasi residents, were the main criteria for inclusion.

Data collection

We conducted face-to-face key informant qualitative interviews (KIIs) with LPG retailers (n = 2 in Kintampo and n = 6 in Obuasi), following an interview topic guide. All interviews were conducted face-to-face between September and November 2020. The interviews explored changes in the supply and demand for LPG before and after the COVID-19 outbreak. This data was supplemented by information collected through open forum discussions among energy stakeholders invited to an engagement workshop organized by the research team in September 2020. The discussions were recorded and explored how the pandemic affected the preparatory and implementation phases of the BCRM pilot in Obuasi. All face-to-face interviews and workshop discussions were conducted adhering to Ghana's COVID-19 preventive guidelines.

All quantitative surveys were administered over the telephone by trained data collectors from Kintampo Health Research Centre. The survey was designed with the Survey Solutions data collection software and administered via telephone by trained data collectors from KHRC. The questionnaire focused on household choice of primary and secondary cookstoves and fuels, cooking practices, household incomes, and expenditures during COVID-19. In Obuasi, the data was compared to the 2019 CLEAN-Air (Africa) baseline survey,[19] which evaluated household access to and use of clean fuels. Having data from households prior to the pandemic provided a unique opportunity to compare households' clean cooking experiences before and during the pandemic.

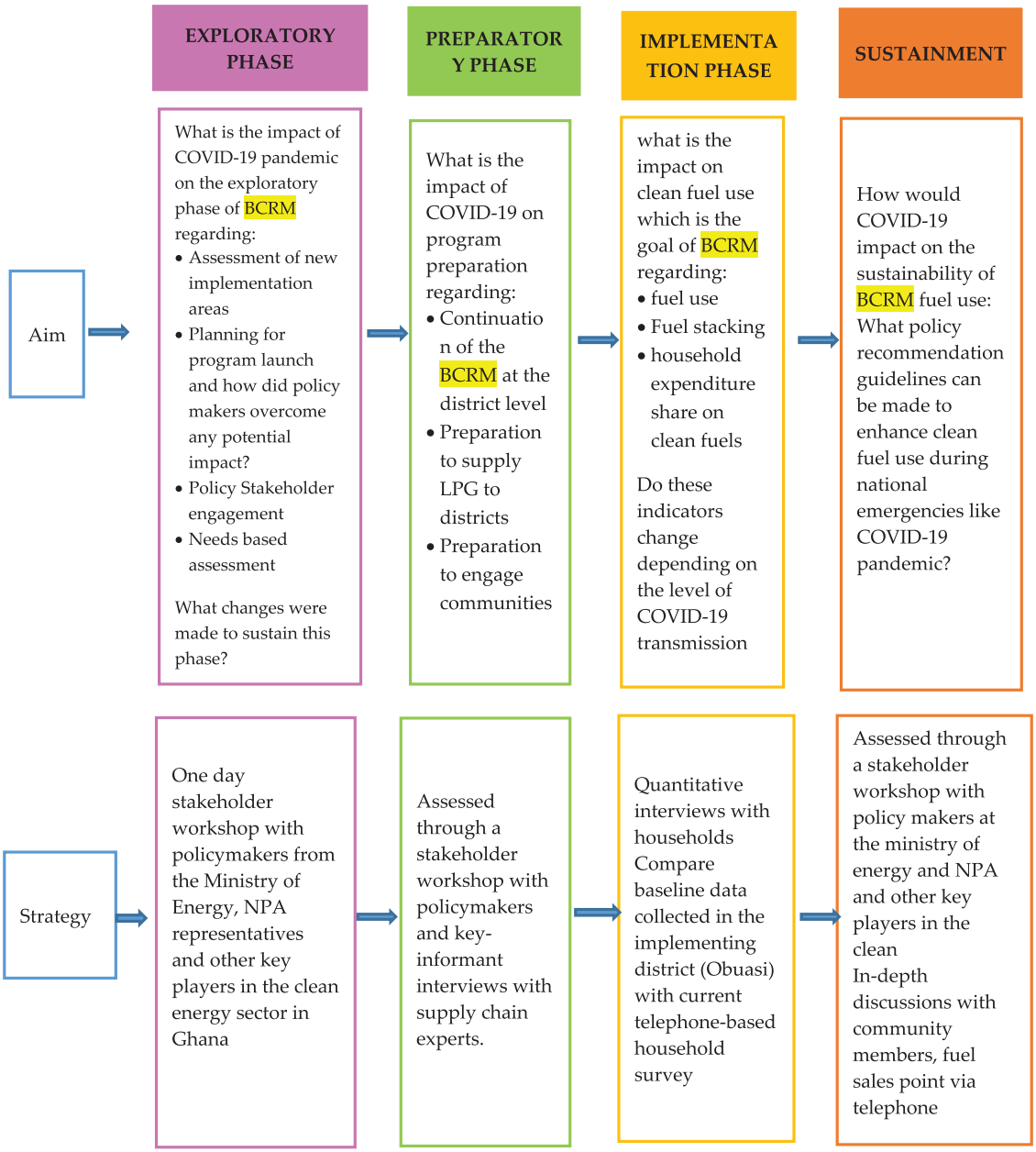

Figure 1. The EPIS framework.

Data analysis

All qualitative data were transcribed verbatim from Twi to English and then exported to Nvivo [version 12], a text-based qualitative data management software for coding. Thematic analysis was used to analyze the data.[25]

The quantitative survey data were analyzed using Stata [version 16]. Descriptive statistics involving frequencies and percentages were used to summarize participant socio-demographic characteristics. The impact of the pandemic on household fuel choices was also assessed with basic descriptive statistics contrasting responses before and during the pandemic. A chi-square test was used to assess factors associated with the impact of the pandemic on household fuel choice.

Ethical approval

The study received ethical approval from the Kintampo Health Research Centre Institutional Ethics Committee (KHRCIEC/2020-14) and by the University of Liverpool Central Ethics Committee. Study participants were consented and assured of anonymity and confidentiality of their identity and responses.

Results

The results of this study are presented following the well-defined phases of the EPIS Framework, which guided the study design. The impacts of the COVID-19 pandemic on the exploratory, preparatory, and initial phases of the BCRM implementation pilot in Obuasi are presented first, reporting

results of the KIIs interviews and workshop discussions, followed by the impacts on clean cooking fuels' use among households before and after the pandemic.

COVID-19 and the implementation of the BCRM policy

Interviews conducted during the stakeholder workshop indicated how the pandemic restrictions had affected NPA's ability to carry out their preparatory works and data collection with households prior to launching the BCRM pilots across national territories. A participant recalled that:

> *"And then we had approval for baseline study prior to the pandemic but couldn't do it because of the COVID restrictions and even for the next phase we might not be able to go and do it, for Jomoro and Yendi (*designated districts for BCRM pilot*)."* [stakeholder workshop participant]

Consequently, key scheduled activities to support the launch of the pilot including the supply of LPG and cylinders to designated pilot districts were ceased: a participant explained:

> *"Supply of cylinders to the pilot areas was halted, Production by Ghana Cylinder Manufacturing Company was also delayed because staff rotation had been introduced."* [stakeholder workshop participant].

Similarly, in areas such as Obuasi where the pilot had started before the outbreak, we found that there were sharp reductions in the frequency of inspections and monitoring of the BCRM implementation by the designated authorities. These disruptions in the planned monitoring were due to travel restrictions and the "no sleep over" policy for NPA personnel who traveled to pilot areas, as explained below:

> *"It had an effect as far as inspections and monitoring were concerned. It reduced the frequency of the monitoring and inspections that were ongoing because the authority now has to make sure that no team sleeps over* [during travels]. *In Obuasi especially, most inspection activities were put on hold since it recorded one of the highest number of infections in the Ashanti region"* [stakeholder workshop participant].

Our interviews also indicated that face-to-face engagements with key stakeholders in the LPG sector were all negatively hit by the COVID-19 outbreak. These engagements were designed to raise awareness and build community acceptance for the new LPG distribution model. Government-imposed restrictions on public gatherings implied that the planned stakeholder engagements were stopped. In instances where the meetings were held, participants were fewer in number, as narrated below:

> *"Well, instead of doing a more detailed one- on- one. . ., we did the launch with fewer numbers. We reduced the number of stakeholders because of the pandemic. E.g., we had over 900 stakeholders* [attending the stakeholder meetings] *before the pandemic, but that was reduced to I think less than 100."* [stakeholder workshop participant]

In other instances, radio, television, and community information channels were used to engage communities:

> *"So COVID-19 helped us to strategize engagement using the media rather than the one-on-one engagement. . ."* [stakeholder workshop participant]

As part of the Government's response to the pandemic, resources were re-directed from different sectors of the economy to support the national fight against the pandemic. Although there was no clear financial shift from LPG financing to COVID-19, budgetary support, and financial allocation to institutions within the sector were reduced, financial timelines were missed, and program rollouts and implementation plans were stalled.

> *"[. . .] plans to start the BCRM pilot in other districts were stalled. . .."*
> *"The ministry had mapped out a few distribution outlets* [as part of the BCRM] *to try the pilot, but all came to a halt."* [stakeholder workshop participant]

The effect of COVID-19 on availability and access to clean cooking fuels

Three interrelated factors that could influence availability and access to clean fuels were identified a priori and explored through qualitative methods: the impact of COVID-19 on the supply, demand, and price of LPG. Data on each of these factors were gathered through KII with LPG marketing companies. In terms of price data, interviewees reported that local prices of LPG were reduced from GH₵5.85 ($0.52)/kg to GH₵4.66 ($0.42)/kg between February and June 2020; amounts also consistent with official sourecs.[26] This decline perhaps may have been driven by the global fall in the demand for petroleum products within this timeframe. Several accounts by LPG retailers also corroborate the reduction in prices over the period:

> *"Before COVID-19, the prices of LPG ranged between GH₵75($6.63) and GH₵80($7.07) per 14kg [cylinder] and during COVID -19 it plummeted to between GH₵63 and GH₵71. So, what I can say is that there was a slight reduction in price."* [LPG Retailer, Kintampo].

> Another respondent observed that *"initially, 17 tons of LPG were bought around GH₵84,000, (*$7427.08) *Yes for 17 tons. During COVID-19, the same 17 tons were sold to us at GH₵74,000, (*$6542.88). *To be honest it reduced. . .Before COVID-19 we already had supply and the following week, when the government made announcement about the pandemic,. . . prices of LPG were reduced further and it affected us.* This view was shared by another retailer in Obuasi, who explained that "*the supply we had was 17 tons and was bought at GH₵84,000, (*$7427.08) *which was higher than the new price we received"* [LPG Retailer, Obuasi].

Yet the reduction in LPG local prices was not as significant as the decrease in the international LPG prices, leading some participants to question the efficiency of the local market.

> *"There shouldn't be that wide difference between what happens on the international market and the local market. Usually, if you have this huge price variation, it tells you that your local market is inefficient because prices on the international market are decreasing by about 80% and the corresponding reduction in the local market is just by about 15%"* [workshop participant].

The results also indicate that import and local production of LPG were briefly interrupted at the beginning of the pandemic whereas a hike in demand for LPG was observed when a lockdown became imminent. A marketer for an LPG company recounted these experiences as follows:

> *". . .Now, this is what happened during the COVID-19 era where we had challenges with supply from the Bulk Distribution Companies (BDCs). There was a disruption because our suppliers could not get the needed quantity to supply LPG retail stations, leading to these kinds of challenges in our supply chain"* [LPG marketer].

For others, the "work from home" policy, which was espoused widely across the world, could have occasioned the supply side challenges that were witnessed. One respondent noted that *"although Ghana produces LPG from the Atoabo plant, not many employees could go to work during the pandemic. The effect therefore was that the volume of LPG production declined and hence you don't get the quantity you need to supply your station"* [LPG marketer].

Survey results before and during the COVID-19 pandemic

Our results cover 800 participants, comprising 400 from Obuasi and Kintampo, respectively. In both study areas, more than 78% of the participants were females and mostly the main cooks for their households. The mean ages were 46 and 38 years for Kintampo and Obuasi, respectively. Most participants in Kintampo (n = 210 (52%)) and Obuasi (n = 226 (56%) were business owners. While more than half of the participants in Kintampo (n = 245 (61.3% belonged to households with 5 or more members, nearly half of the households in Obuasi (n = 197 (49.3%)) had less than 5 members. Table 1 shows the income levels of the household during the pandemic in both study areas. In both study area, majority of the household earned less than GH₵ 250 ($22.1).

COVID-19 and household choice of fuels for cooking

Overall, the use of clean fuel (thus LPG and electricity) among households in both study areas reduces during the pandemic period. In Kintampo, there was a 7.1% decrease in the proportion of households who used clean fuel for primary cooking. However, the reverse was seen in the use of unclean fuel types before and during the COVID-19 pandemic. The use of charcoal and wood as primary cooking fuels increased from 52.0% to 57.8% and 9.0% to 10.3% respectively. Table 2 shows similar results for the Obuasi site, where the use of charcoal increased from 10.8% before the pandemic to 14.8% during the pandemic. While the use of wood did not change before and during the COVID-19 era with respect to Obuasi, there was a 4.1% decrease in the use of clean fuel as the primary source of fuel during the COVID-19 pandemic (Table 2).

Clean fuel use for cooking during COVID-19

About 31% (n = 47) of participants in Kintampo and 40% (n = 141) in Obuasi reported that the COVID-19 pandemic affected their use of LPG for cooking (Table 3). Of these, 63.8% (n = 30) in Kintampo stopped LPG use entirely while about 87.2% (n = 123) of respondents in Obuasi cut back on the use of LPG for cooking. This was mainly because they could not afford to buy the fuel (Kintampo = 86.8%; Obuasi = 26.9%) or suffered a reduction in income (Kintampo = 31.6%; Obuasi = 93.1%). Interestingly, 19.2% (n = 9) in Kintampo and 7.8% (n = 11) in Obuasi increased their LPG use during the pandemic. Increased frequency of cooking activities perhaps due to children being at home was a common reason why some households used more LPG.

Factors that affected clean fuel choice during the COVID-19 pandemic

To assess the impact of factors that influence household choice of clean fuel use during the pandemic, we performed a chi-square test among respondents who reported changes in their primary fuel. Table 4 shows that in both study areas, most households likely to switch from the use of clean fuel were those whose average weekly or monthly income is less than GH₵500 ($44.21). This however was not a statistically significant factor at 5% level ($P = .304$). Similarly, analysis of the effect of household size showed that most households with a switch in clean fuel had an average of 6 to 10 persons per household in Kintampo, and about 5 persons per household in Obuasi. This result was a statistically significant factor in both Kintampo ($P = .004$) and Obuasi ($P = .047$). Regardless of the study site, respondents' occupation did not seem to influence the choice of clean fuel use during the pandemic period.

Discussion

This study is among the first to explore the effects of COVID-19 restrictions on clean cooking fuel use in Ghana. The study also assessed the effect of government control measures on the pilot implementation of the BCRM—a new government policy changing LPG distribution in Ghana. Our findings showed that the pandemic control measures affected major activities which were expected to be implemented as part of the BCRM pilot by national authorities. The activities included, but were not limited to, supply of newly manufactured branded cylinders to the pilot districts, face-to-face engagements with stakeholders in the LPG sector and regular inspections and monitoring of BCRM depots. This result agrees with recent studies that

Table 1. Demographic characteristics of study participants (n = 800).

VARIABLE	`KINTAMPO	OBUASI
	N (%)	N (%)
Gender		
Female	315 (78.7)	314 (78.5)
Male	85 (21.3)	86 (21.5)
Participants' age		
18-24	11 (2.8)	53 (13.3)
25-40	158 (39.5)	200 (50.0)
41-59	161 (40.2)	123 (30.8)
60+	70 (17.5)	24 (6.0)
Main cook for the household		
Yes	308 (77.0)	355 (88.8)
No	92 (23.0)	45 (11.3)
Household size		
1-4 persons	116 (29.0)	197 (49.3)
5-9 persons	245 (61.3)	189 (47.3)
10 and above persons	39 (9.7)	14 (3.5)
Number of children below 17		
None	58 (14.5)	73 (18.3)
1-4 children	292 (73.0)	303 (75.8)
5-9 children	47 (11.8)	23 (5.8)
10 and above children	3 (0.8)	1 (0.3)
Number of adults above 17		
1-4 adults	319 (79.8)	360 (90.0)
5-9 adults	75 (18.8)	39 (9.8)
10 and above adults	6 (1.5)	1 (0.3)
Occupation		
Farmer	19 (4.7)	11 (2.8)
Paid employment	27 (6.7)	51 (12.8)
Business owner	210 (52.5)	226 (56.5)
Apprentice	7 (1.7)	12 (3.0)
Government	48 (12.0)	30 (7.8)
Unemployed (looking for work)	63 (15.8)	56 (14.0)
Student	11 (2.8)	9 (2.3)
Retired	15 (3.8)	5 (1.3)
Household average weekly incomes		
No regular income	100 (25)	91 (22.8)

(Continued)

Table 1. (Continued)

VARIABLE	`KINTAMPO	OBUASI
	N (%)	N (%)
<GH₵250 ($22.10)	161 (40)	127 (31.7)
GH₵250-GH₵500 ($44.21)	25 (6.3)	67 (16.8)
>GH₵500 ($44.21)	19 (22.8)	101 (25.2)
Do not know	23 (5.8)	14 (3.5)

Table 2. Household primary fuel used for cooking before and during COVID-19.

PRIMARY FUEL USAGE	KINTAMPO		OBUASI	
	BEFORE N (%)	DURING N (%)	BEFORE N (%)	DURING N (%)
Clean fuel	153 (38.3)	124 (31.0)	352 (88.0)	336 (84.0)
Charcoal	208 (52.0)	231 (57.8)	43 (10.8)	59 (14.8)
Wood	36 (9.0)	41 (10.3)	4 (1.0)	4 (1.0)
No fuel	3 (0.8)	4 (1.0)	1 (0.2)	1 (0.2)

The period before COVID-19 refers to the months before March 2020 when Ghana had not yet recorded any cases of COVID-19. The first case was recorded in March 2020. The period during COVID-19 is defined to include the last 30 days before the surveys were conducted (between September and November 2020).

Table 3. Use of clean fuel[a] (LPG/electricity) for cooking during COVID-19.

HAS THE COVID-19 RESPONSE AFFECTED HOW MUCH LPG YOU USE FOR COOKING?	KINTAMPO	OBUASI
	N (%)	N (%)
Yes	47 (30.7)	141 (40.1)
No	106 (69.3)	211 (59.9)
How has your use of LPG been affected?		
Stopped using LPG	30 (63.8)	7 (5.0)
Cut down on LPG use	8 (17.0)	123 (87.2)
Increased use of LPG	9 (19.2)	11 (7.8)
REASON FOR STOPPING OR DECREASING THE USE OF LPG[B]	**KINTAMPO**	**OBUASI**
	N (%)	N (%)
Cannot afford it	33 (86.8)	35 (26.9)
Unable to go out to obtain it	0 (0.0)	1 (0.8)
Reduced income	12 (31.6)	121 (93.1)
Change in the quantity of food cooked	1 (2.6)	2 (1.5)
Other	2 (5.3)	2 (1.5)
Reason for increasing the use of LPG		
Change in type/quantity of food cooked	5 (55.6)	0 (0.0)
Cooking for less people/shorter amount of time	0 (0.0)	8 (72.7)
Increased frequency of cooking	4 (44.4)	3 (27.3)

[a]The values for electricity were very small and had to be added to those of LPG to form this category.
[b]Multiple answers were allowed.

Table 4. Factors impacting on choice of clean fuel for cooking during COVID-19 pandemic.

HAS THE COVID-19 RESPONSE AFFECTED HOW MUCH CLEAN FUEL YOU NOW USE?	KINTAMPO			OBUASI		
	YES (%) N = 47	NO (%) N = 106	*P*-VALUE	YES (%) N = 141	NO (%) N = 211	*P*-VALUE
Total weekly/monthly income						
<GH₵500 ($44.21)	22 (62.9)	42 (42.5)	.304	72 (62.6)	93 (66.0)	
>GH₵500 ($44.21)	13 (37.1)	38 (47.5)		43 (37.4)	52 (34.0)	.578
Household size						
1-2 persons/HH	2 (4.3)	25 (23.6)	.004	16 (11.4)	38 (19.4)	
Above 2 persons/HH	45 (95.7)	81 (76.4)		125 (88.6)	158 (80.6)	.047
Occupation						
Paid employment	13 (27.7)	32 (30.2)		26 (18.4)	44 (22.5)	
Business owner	28 (59.6)	46 (43.4)	.102	91 (64.5)	106 (54.1)	
Not employed	6 (12.8)	28 (26.4)		24 (17.0)	46 (23.5)	.194

demonstrate the adverse impacts of COVID-19 on energy transitions efforts including a renewable energy transition program in Denmark[27] and clean cooking initiatives in India.[28] Besides the government's failure to secure private capital investment for the establishment of large-scale LPG bottling plants as part of the transition to the new distribution model, other consequences of the pandemic on clean energy efforts in Ghana included brief interruptions of LPG importation and local production between April and June 2020. However, the disruption lasted for a short period of time and the supply of LPG was minimally affected. This assessment is supported by results from the qualitative interviews with LPG purveyors and data from the NPA, suggesting that the impact of the pandemic on the consumption of LPG for cooking was short-lived, as demand for the product recovered after the lockdown and recorded an 11% increase at end of 2020.[29] Overall, it appears that Government measures that facilitated continued work for essential service providers, including those in the energy sector, during the partial lockdowns in Accra and Kumasi, may have contributed to the availability of clean fuels for cooking. This part of the results contrasts with the experiences in Ecuador,[30] where a robust transport arrangement facilitated LPG deliveries during the pandemic, and thus ensured that LPG supply remained sufficiently available for household use.

Further to the impacts of the COVID-19 on the BCRM program and the supply of LPG, gathered from the qualitative interviews, results from the household survey also suggest significant linkages between the introduction of pandemic restrictive measures and changes in household use of LPG as a clean cooking fuel. Changes were reported among 40.1% of survey respondents in Obuasi and 30.7% in Kintampo, with these household mostly changing from LPG to charcoal. Across the 2 study areas, cessation of LPG use was highest among households in Kintampo (63.8%). In Obuasi, 87.2% of households cut back on use of LPG for cooking while 7.8% and 19.2% increased its use in Obuasi and Kintampo respectively. While the increases in use of LPG during the pandemic was attributed to the upsurge in cooking activities resulting from likely increase in household members (either children being at home for longer hours due to school temporary closures or extra adults unable to go to work due to the lockdown), households' decision to stop or cut back on the use of LPG were primarily driven by financial constraints (Obuasi = 93.1%; Kintampo = 31.6%). This finding is consistent with those reported by Shupler et al[31] who found that households that had lower consumption before the lockdown but experienced more loss of income due to the restrictions, were more likely to switch from LPG to other fuels. In the context of large-scale outbreaks like COVID-19, the effect of fallen incomes on access to and use of LPG for cooking can especially be stunning. Ali and Khan[32] in a recent study in India reported a considerable transition from clean to polluting fuel use due mainly to COVID-19 related income loses and disruptions to LPG supply. In one community (Bihar) for instance, the study found that access to clean fuel had reduced from 40% in 2018 to 17% during the pandemic period in 2020. These results, taken together, are consistent with previous findings that both cost of LPG and household income are key determinants of household use of LPG for cooking.[33-35]

By highlighting how the COVID-19 pandemic restrictions affected household choice of clean fuel for primary cooking, as well as government initiatives to boost uptake for LPG in Ghana, this study provides insights that could be valuable in

future understanding of the interactions between pandemic control measures and economic disruptions that may affect household energy choices for cooking. A limitation of the study is that it was conducted in the early stages of the pandemic (September to November 2020), and it's likely that our findings might reflect only the short-term impacts of the pandemic as opposed to the overall long-term effects. Thus, future studies, directed at exploring the long-term impacts of the COVID-19 outbreak on clean cooking fuel use in Ghana would be useful additions to clean cooking implementation policy guides.

Conclusions

Despite the relevance of sustained clean cooking to the attainment of several development goals, few studies in sub-Saharan Africa have been undertaken to document the dynamics of clean energy use and government policy choices during adversities such as COVID-19 pandemic. Our study assessed how restrictive measures introduced following the outbreak of COVID-19 in Ghana, affected the availability and use of clean energy for cooking. The results showed that while LPG supply from both import and local production sources experienced minimal disruptions at the peak of the infection in Ghana. The fuel remained available during the pandemic period—due to a government initiative that facilitated continued work for essential service providers, including those in the energy sector. Changes in household incomes during the pandemic had the biggest percentage effect on household choice of cooking fuel, causing a regression in some cases, to polluting fuel use. In other cases, LPG continued to be the choice of fuel for a significant number of households, although the prevalence was higher in Obuasi than Kintampo. In terms of impacts on the implementation of the BCRM across selected pilot areas, the roll out was adversely impacted, with planned data collection and stakeholder engagements being the most affected. As Ghana pushes forward with the implementation of the BCRM policy post-COVID-19 pandemic, there is urgent need for policy recognition of LPG as a basic need. Such consideration and policy prioritization are critical to displacement of solid fuel use, and to avoid potential cutbacks in LPG use and/or reversions to biomass fuel due to limited incomes among the poor. It is equally imperative that in future emergencies like COVID-19, subsidized LPG prices for clean cooking—similar to the free electricity provision for the poor, and the 50% reduction in electricity cost for other consumers as announced by the government of Ghana during the pandemic—are implemented to shield households from the potential health risks associated with regression to use of polluting fuels.

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Author Contributions

RKDP, TT, KPA DJ, EP, DP, conceived the idea, contributed to the design, data collection, analysis, interpretation, and drafting of the manuscript. SWA, MM, JS, IS, JW contributed to design, collection of data, interpretation and drafting of the manuscript. RT, SG, MT managed and analyzed the data. All authors gave approval for the final version to be published.

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REFERENCES

1. The World Bank. *The Global Economic Outlook During the COVID-19 Pandemic: a Changed World*. The World Bank; 2020.
2. UNIDO. *Coronavirus: The Economic Impact*. UNIDO; 2020.
3. Pak A, Adegboye OA, Adekunle AI, Rahman KM, McBryde ES, Eisen DP. Economic consequences of the COVID-19 outbreak: the need for epidemic preparedness. *Front Public Health*. 2020;8:241.
4. Rogan M, Skinner C. *WAVE 1 The COVID-19 Crisis and the South African Informal Economy*. United Nations University World Institute for Development; 2020.
5. Turkan M. COVID-19 and the Informal Sector: what it means for women now and in the future [Internet]. 2020. Accessed May 20, 2021. https://giwps.georgetown.edu/wp-content/uploads/2020/07/GIWPS_Covid19_July2020.pdf
6. Hosier RH, Dowd J. Household fuel choice in Zimbabwe. An empirical test of the energy ladder hypothesis. *Resour Energy*. 1987;9:347-361.
7. Kaali S, Jack DW, Delimini R, et al. Household air pollution exposure and mitochondrial DNA copy number in cord blood: Identifying sensitive windows and sex-specific effects. *Am J Respir Crit Care Med*. 2018;197:A1024.
8. Kaali S, Jack D, Delimini R, et al. Prenatal household air pollution alters cord blood mononuclear cell mitochondrial DNA copy number: sex-specific associations. *Int J Environ Res Public Health*. 2018;16:1-12.
9. Lee KK, Bing R, Kiang J, et al. Adverse health effects associated with household air pollution: a systematic review, meta-analysis, and burden estimation study. *Lancet Glob Heal*. 2020;8:e1427-e1434.
10. Weagle CL, Snider G, Li C, et al. Global sources of fine particulate matter: interpretation of PM2.5 chemical composition observed by SPARTAN using a global chemical transport model. *Environ Sci Technol*. 2018;52:11670-11681.
11. Li G, Hao Y, Yang T, et al. Air pollutant emissions from sludge-bituminous briquettes as a potential household energy source. *Case Stud Therm Eng Internet*. 2022;37:102251.
12. WHO. Household air pollution. 2022. Accessed March 1, 2023. https://www.who.int/news-room/factsheets/detail/household-air-pollution-and-health
13. Service, Ghana Statistical. Ghana 2021 population and housing census. General report: volume 3K. 2022. https://www.statsghana.gov.gh/gssmain/fileUpload/pressrelease/Volume3K_HousingCharacteristics_240222.pdf
14. Asante KP, Afari-Asiedu S, Abdulai MA, et al. Ghana's rural liquefied petroleum gas program scale up: a case study. *Energy Sustain Dev Internet*. 2018;46:94-102.
15. Baneseh MA. The cylinder recirculation model-all you need to know - graphic online [Internet]. *Graphiconline*; 2018. Accessed June 15, 2020. https://www.graphic.com.gh/features/features/the-cylinder-recirculation-model-all-you-need-to-know.html
16. 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;3:370-390.
17. WHO. *Coronavirus Disease 2019 (COVID-19) Situation Report 92*. WHO; 2020.
18. Kenu E, Odikro MA, Malm KL, et al. Epidemiology of COVID-19 outbreak in Ghana, 2020. *Ghana Med J*. 2020;54:5-15.
19. 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;6:1198-1210.
20. Office of the President Republic of Ghana. President Akufo-Addo on updates to Ghana's enhanced response to COVID-19 - The Presidency, Republic of Ghana [Internet]. 2020. Accessed June 15, 2022. https://www.presidency.gov.gh/

index.php/briefing-room/speeches/1560-president-akufo-addo-speaks-on-updates-to-ghana-s-enhanced-response-to-COVID-19
21. Aarons GA, Hurlburt M, Horwitz SM. Advancing a conceptual model of evidence-based practice implementation in public service sectors. *Adm Policy Ment Health Ment Health Serv Res*. 2011;38:4-23.
22. Moullin JC, Dickson KS, Stadnick NA, Rabin B, Aarons GA. Systematic review of the exploration, preparation, implementation, sustainment (EPIS) framework. *Implementation Sci*. 2019; 14, 1.
23. Ghana Statistical Service. Kintampo north district. 2014. Accessed September 20, 2021. https://www2.statsghana.gov.gh/docfiles/2010_District_Report/BrongAhafo/KintampoNorth.pdf
24. Ghana Statistical Service. 2010 population and housing census. District analytical report: Obuasi Municipality. 2014. Accessed September 20, 2021. https://www2.statsghana.gov.gh/docfiles/2010_District_Report/Ashanti/OBUASI.pdf
25. Braun V, Clarke V. Thematic analysis. In: Cooper H, Camic PM, Long DL, Panter AT, Rindskopf D & Sher KJ (Eds.). *APA Handbook of Research Methods in Psychology, Vol 2: Research Designs: Quantitative, Qualitative, Neuropsychological, and Biological*. Vol. 2. American Psychological Association; 2012:57-71.
26. National Petroleum Authority. Indicative prices [Internet]. 2021. https://www.npa.gov.gh/download-media/industry-data/indicative-prices
27. Shah MI, Kirikkaleli D, Adedoyin FF. Regime switching effect of COVID-19 pandemic on renewable electricity generation in Denmark. *Renew Energy*. 2021;175:797-806.
28. Ravindra K, Kaur-Sidhu M, Mor S, Chakma J, Pillarisetti A. Impact of the COVID-19 pandemic on clean fuel programmes in India and ensuring sustainability for household energy needs. *Environ Int*. 2021;147:106335.
29. National Petroleum Authority. Downloads [Internet]. 2020. Accessed March 20, 2022. https://www.npa.gov.gh/download-media/industry-data/downloads
30. Valarezo A, Dávila L, Bejarano ML, et al. Resilient clean cooking: maintaining household clean cooking in Ecuador during the COVID-19 pandemic. *Energy Sustain Dev J Int Energy Initiat*. 2023;74:349-360.
31. Shupler M, Mwitari J, Gohole A, et al. COVID-19 impacts on household energy & food security in a Kenyan informal settlement: the need for integrated approaches to the SDGs. *Renew Sustain Energ Rev*. 2021;144:111018.
32. Ali J, Khan W. Factors affecting access to clean cooking fuel among rural households in India during COVID-19 pandemic. *Energy Sustain Dev*. 2022;67:102-111.
33. Karimu A, Mensah J, Adu G. Who adopts LPG as the main cooking fuel and why? Empirical evidence on Ghana based on national survey. *World Dev*. 2016;85:43-57.
34. Abdulai MA, Afari-Asiedu S, Carrion D, et al. Experiences with the mass distribution of LPG stoves in rural communities of Ghana. *EcoHealth*. 2018;15:757-767.
35. Gould CF, Urpelainen J. LPG as a clean cooking fuel: adoption, use, and impact in rural India. *Energy Policy*. 2018;122:395-408.