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Complex dynamics in sustaining clean cooking and food access through a pandemic: A COVID-19 impact study in peri-urban Cameroon

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ABSTRACT

Access to clean energy for cooking is central to achieving Sustainable Development Goal 7. Latest predictions suggest that this goal will not be met by 2030, with further setbacks due to the COVID-19 pandemic. We investigated the impacts of COVID-19 restrictions on household cooking fuel, practices and dietary behaviours in a peri-urban community in Central Cameroon. Using surveys (n = 333) and qualitative semi-structured interviews (n = 12), we found negative financial impacts and high levels of food insecurity, with 83 % and 56 % of households reporting reduced income and insufficient food, respectively. Households reduced food intake and cooking frequency and relied more heavily on local sources (e.g., farmland) to feed their families. Changes in primary cooking fuel were less pronounced and fuel choice was inherently linked to cooking behaviours, with some households utilising LPG more often for simple tasks, such as reheating food. Local systems were key in sustaining food and fuel access and households demonstrated resilience by employing numerous mechanisms to overcome challenges. Our findings underline the vulnerability of households in maintaining sufficient food intake and sustaining clean cooking, highlighting how policy needs to take a nuanced approach considering food-energy dynamics and strengthening local systems to ensure access to clean energy is resistant to system shocks.

Introduction

The COVID-19 pandemic has highlighted the volatility and fragility of global energy and food systems. Their vulnerability has serious implications for our ability to protect and improve population health, national economies, and the environment and to meet the 2030 Sustainable Development Goals (SDGs) (United Nations, 2019), particularly across low- and middle-income countries (LMICs) (Barbier & Burgess, 2020). Emerging evidence suggests the economic pressures the pandemic has placed on households may be associated with a return to the use of polluting fuels for household cooking, which will increase exposure to household air pollution (HAP) and damage health (Ali & Khan, 2022).

An estimated 2.4 billion people, mainly in lower- and middle-income countries, rely on polluting fuels, such as wood, charcoal, and biomass, for household energy activities (IEA, IRENA, UNSD, World Bank, & WHO, 2022). Use of polluting household fuels contributes significantly to the global burden of disease, being causally related to a range of non-communicable respiratory and cardiovascular diseases and childhood pneumonia. In sub-Saharan Africa (SSA), where over 900,000 people are dependent on polluting fuels for their household energy (IEA, 2020), an estimated 9 % of total annual mortality and 7 % of morbidity is attributed to exposure to HAP (Lee et al., 2020). "Ensur[ing] access to affordable, reliable, sustainable and modern energy for all" (SDG 7) is key to improving population health (United Nations, 2019). Central to this goal is to provide households with access to clean energy for cooking, heating, and lighting to improve indoor air quality (WHO, 2014, 2021b). In addition to health benefits, the transition to clean household energy will bring substantial climate, environmental, and economic co-benefits, and support gender equity (IEA, 2020). Before the arrival of COVID-19, progress in meeting SDG 7 was slow, with gains in clean fuel adoption rates being outpaced by population growth (Stoner et al., 2021). The pandemic threatens to further stall (or even reverse) progress towards achieving universal sustained use of clean household energy, unless the international community takes urgent action. Understanding the impacts of the COVID-19 pandemic on energy and food systems may contribute to the improved resilience of household energy systems in resource-poor settings.

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The COVID-19 pandemic's potential impacts on household energy insecurity and effects on physical and mental health were recognised in the early stages of the pandemic (Brosemer et al., 2020; Graff & Carley, 2020). Graff & Carley warned the increased economic hardship in the United States of America (USA) would increase energy insecurity and endanger health as households would rely on dangerous fuel sources (e.g., burning trash for heat), be unable to maintain comfortable temperatures and forgo other basic needs (such as food and medical care) and recommended increased support for low-income households (Graff & Carley, 2020). Evidence now indicates that COVID-19 exacerbated household energy insecurity in the USA, with its impacts found to be statistically associated with predictors of energy poverty (inability to pay bills or risk of disconnection from suppliers) (Memmott, Carley, Graff, & Konisky, 2021). Household energy consumption was also found to increase, for example, in Brazil, household consumption increased by 5 % in the early phase of the pandemic – likely due to children staying home (Simões & Leder, 2022) and Cheshmehzangi (2020) found that energy use for cooking increased by 40 % in China. This increased energy demand is likely to aggravate household energy insecurity. The impacts of the pandemic on the most energy insecure households are not known, however, as the literature has predominantly focused on high-income countries (Brosemer et al., 2020) or the impacts on urban-level energy systems (Rowe, Robinson, & Patias, 2022).

A few studies have sought to assess whether the use of clean household energy for cooking was sustained during the pandemic. A survey-based study conducted in an informal settlement in Nairobi, Kenya, found reverse switching among a quarter of households who, before the pandemic, had primarily cooked with cleaner burning fuels (Shupler, Mangeni, et al., 2021). Reverting to polluting fuels was associated with previous lower liquefied petroleum gas (LPG) consumption and greater income loss during lockdown (Shupler, Mwitari, et al., 2021). Similarly, in an informal settlement in western Kenya, 18 % of households using LPG as primary fuel switched to polluting fuels (wood, charcoal, or kerosene) (Shupler et al., 2022). Further research in Kenya revealed how pay-as-you-go LPG helped support Nairobi households to sustain access to LPG during COVID-19 (Shupler, O'Keefe, et al., 2021). In India, clean cooking access among rural households decreased from 35 % in 2018 to 20 % during COVID-19, following a socio-demographic gradient (Ali & Khan, 2022). Ravindra et al. use the DPSIR (Driving, Forces, Pressures, State, Impact, Responses) Framework to understand the impacts of COVID-19 on clean fuel programmes and make recommendations for ensuring access, but do not study the impacts at a household level (Ravindra, Kaur-Sidhu, Mor, Chakma, & Pillarisetti, 2021). While there is emerging evidence of the impacts of the COVID-19 pandemic on sustained access to clean cooking fuels, further evidence in additional settings, such as Sub-Saharan Africa with a high reliance on polluting cooking fuels, and studies that incorporate qualitative methods to explain these impacts, will pinpoint where to concentrate national and international efforts to achieve sustained clean cooking for all.

To understand the impact of the COVID-19 pandemic on households' socioeconomic situation, fuel, and food access in a different sub-Saharan African setting, we conducted a mixed-methods study in the peri-urban community of Mbalmayo in central Cameroon. This research was conducted under CLEAN-Air(Africa), a global health research programme, which aims to provide evidence to inform national development of policies that address the burden of non-communicable disease from HAP exposure and support sustained transition to clean cooking fuels (Puzzolo et al., 2019). CLEAN-Air(Africa)'s work focused on three countries (Kenya, Cameroon, Ghana) whose Governments have committed to scale up cleaner burning fuels including LPG as a transition fuel, under the Sustainable Energy for All initiative (IEA, 2020; SE4All, Ghana, Commission, & Ghana, 2012; SE4All & Petroleum, 2016). In response to the COVID-19 pandemic, CLEAN-Air(Africa) refocused its research efforts in these countries to understand the impact of the pandemic on household fuel use, cooking practices and income and food security. The study employed a mixed-methods approach, utilising survey and semi-structured interview data collection tools to capture changes in households' use of cooking fuels, and cooking practices. We explored factors influencing household access to cooking fuels and food and interpreted these in the context of changes to households' socioeconomic situation and broader economic impacts.

Background – household energy and COVID-19 in Cameroon

The household energy context

Two-thirds of Cameroonians are reliant on polluting fuels for daily cooking (INS, 2020). Firewood burned on three-stone fires is the predominant cooking method, used by 62 % of the population (INS, 2020), not only to prepare meals and reheat food but also to boil water for drinking and bathing (Pope et al., 2018; Pye et al., 2020). Other polluting fuels - charcoal, and kerosene - account for 4 % and 3 % of primary fuel use, respectively. Typical foods cooked in Cameroon include cassava and plantain, which are traditionally cooked slowly using firewood. The proportion of the population using cleaner burning LPG as a primary fuel has increased in the last decade from about 18 % of the population in 2011 to 25 % in 2018 (with much higher usage in urban areas (43 %) compared with rural areas (3 %)) (INS, 2020). Fuel stacking (combining LPG with polluting fuels) is common, but typically not recorded in national survey data (INS, 2020). Only 0.8 % of the population uses electricity for cooking, a proportion which has seen a minimal increase from 0.1 % in2011 (INS, 2020). The Cameroonian Government recognises LPG as the most rapidly scalable and viable transition fuel for its population on the path towards producing energy from renewable sources (including bioLPG) (Rubinstein, Betang, Mbatchou, Pope, & P, 2021) and set a goal in 2016 to increase primary use of LPG to 58 % of the population by 2030 in a national Masterplan (Bruce et al., 2018; GLPGP, 2016; SE4All, 2016).

Modelling conducted by CLEAN-Air(Africa) estimates that fulfilment of the national LPG scale up target would avert 28,000 deaths and 770,000 disability-adjusted life years (ADALYS) with no negative climate impacts (Kypridemos et al., 2020). The Masterplan for LPG scale up detailed the financial investment (€400 million) needed to increase the number of LPG cylinders in circulation, improve storage, filling and distribution capabilities, as well as strengthen regulation and ensure safety enforcement (Bruce et al., 2018). Cameroon has made some progress in implementing the Masterplan, including completion of a deep-water port in the coastal city of Kribi to increase import capacity. Full implementation, however, has been hampered by the absence of a consolidated investment plan for bulk cylinder acquisition, a prerequisite for market expansion. The financial crisis triggered by the global pandemic is likely to have further slowed the country's progress in scaling up population access to LPG and our study elucidates some of the obstacles to access faced by households, especially among the most vulnerable groups.

The COVID-19 pandemic

COVID-19 and the associated measures to control the spread of the virus have caused widespread and continued disruption to all aspects of life in Cameroon – health, security, political, economic, and social – in a pattern consistent with the global experience (OCHA, 2021; WHO, 2021a). During the study period and up to 10th December 2021, the World Health Organization (WHO) reported 107,549 confirmed COVID-19 cases and 1823 deaths in the country (WHO, 2020). Rates (cases and deaths) have been much lower than first anticipated, even allowing for underreporting. In line with most of SSA, COVID-19 case, hospitalization and death rates in Cameroon remained relatively low throughout 2020 after the first confirmed case on 6th March 2020 (Siewe Fodjo et al., 2021).

Government response to COVID-19

A variety of national public health measures were implemented to prevent the transmission of COVID-19, initially centred on thirteen measures, including: closing educational and training establishments and sea borders, suspending incoming flights, discouraging internal travel, prohibiting gatherings of >50 people, a curfew on entertainment venues from 6 p.m., and postponing sporting events (Secretariat General, 2020a, 2020b; Prime Minister's Office, 2020a, 2020b). National control measures were reinforced by the promotion of WHO guidance on individual preventative measures, such as regular hand hygiene, physical distancing and respiratory etiquette (Secretariat General, 2020b, 2021; Siewe Fodjo et al., 2021). Face masks were mandated in public spaces from April 2020 (Siewe Fodjo et al., 2021). These measures led to significant changes to daily life in Cameroon, with our study investigating their impacts on households' ability to sustain access to an adequate supply of food and cleaner cooking fuels during the pandemic.

Methods

Study setting

This study was conducted between July and September 2020 in MBalmayo, a peri-urban town in the Centre Region of Cameroon (>60,000 population) located a 45-minute drive south of the country's capital Yaounde. Case and death rates had reduced during the study period (following an initial rise from May to July 2020) and remained low throughout. The government's COVID-19 control measures, as well as mandated mask wearing, were introduced prior to the study start and remained in place.

Sampling frame

The sampling frame for this study was drawn from previous research conducted in the study community by the CLEAN-Air(Africa) Global Health Research Group. Phase 1 comprised a population-based "census" survey (April 2019) administered to the primary cook (predominantly females) or head of household ($n = 2000$) to obtain information on household demographics and cooking fuel practices (Shupler et al., 2021). A follow-up in-depth survey (Phase 2) was conducted between May and June 2020 with a sub-sample of 438 census survey participants from Mbalmayo (following stratified sampling to detect differences in systolic and diastolic blood pressure between fuel using groups) to understand their fuel use, cooking behaviours, fuel practices, and health and wellbeing in more depth (details of the sample and calculation are provided in Appendix A). Households that had taken part in the in-depth survey (phase 2) (i.e., households with surveys completed on health and well-being) were initially targeted to take part in this separate COVID-19 impact study. Households from phase 1 that used LPG as primary cooking fuel were then targeted to achieve a sample size of $n > 300$ after households from phase 2 were exhausted.

Survey and quantitative analysis

A telephonic survey was conducted with consenting households and data was collected via Mobenzi Researcher online platform, a mobile phone application with secure cloud storage. Trained interviewers administered the survey questionnaire, which contained questions on household demographics, cooking activities and fuel acquisition. Questions capture changes in cooking patterns that could be attributed to changing living conditions under COVID-19 lockdowns. Questions and responses were tested for appropriateness in the local context with input from the local field team, for example options for food types were based on discussion with local staff around staple foods. Survey data was cleaned and analysed using R version 4.0.3 (R Core Team, 2017).

Semi-structured interviews and qualitative analysis

Qualitative semi-structured interviews (SSIs) were undertaken by telephone with selected survey participants to understand the potential effects of COVID-19 and national control measures on people living in the community. Qualitative research participants were recruited from households that had taken part in the COVID-19 survey as well as both CLEAN-Air(Africa) surveys and qualitative interviews conducted before the pandemic, between July and September 2019. The researchers employed purposive sampling to select participants with a range of demographic and other characteristics of interest to the study; including socioeconomic indicators, cooking patterns and fuel use. The topic guide focused on the impacts of COVID-19 restrictions on fuel use, food access and cooking activities, as well as other changes to the household situation. Emerging issues from the interview data informed subsequent selection of participants to obtain a variety of perspectives and the focus of further inquiry. We aimed to interview between 8 and 12 households to capture changes and achieve thematic saturation of qualitative data (Guest & Chen, 2020). Data collection continued until saturation had been reached at 12 interviews, which was assessed through discussions with the research team on themes emerging from the data. The interviews lasted around 1 hour and were conducted by mobile phone. Interviews were audio recorded, transcribed and translated from French to English for analysis.

The framework method was used to guide data collection and analysis processes. This method was designed for use in applied research and has been employed successfully to inform policy and practice within health research (Gale, Heath, Cameron, Rashid, & Redwood, 2013). The systematic approach has seven stages: transcription; familiarisation with the interview; coding; development of the analytical framework; application of the analytical framework; charting data and interpretation of the data. A collaborative process, involving four researchers who convened at regular intervals, was employed to ensure consensus and consistency. Following the interview transcription (stage 1), researchers read through the transcript to become familiar with the data (stage 2). The researchers then coded a single transcript based on pre-defined areas of interests informed by the research questions, but were free to open-code other relevant occurrences in the text (stage 3). Following this initial coding, an analytical framework was agreed and tested before being applied to all transcripts (stages 4 & 5). To control for differences between researchers, all transcripts were double coded for consistency; a high level of agreement (90 %+) was found. Subsequently, a framework matrix (stage 6) was developed. The summaries from stage 6 were used in the interpretation of the data and concepts were generated through mapping connections and discussion with the analysis team. A workshop with the wider research team was held to verify the concepts, and wider literature was used to reinforce the findings. We used Nvivo Pro 2020 software to support data management and analysis (QSR, 2020).

Ethics

Ethical approval for this study was obtained from the University of Liverpool, United Kingdom and the Central Regional Ethics Committee for Human Health Research in Cameroon. Survey and qualitative interview participants provided informed verbal consent before taking part and were compensated for their time with a small allocation of mobile airtime.

Results

In this section, results from the survey on the impacts of COVID-19 on household circumstances, food security, cooking practices along with cooking fuel consumption and choice, are presented first. The semi-structured format of the qualitative interviews allowed the research team to explore the reasons behind the changes documented

in the quantitative surveys in more depth, including reasons for moving towards and away from LPG. Results from the qualitative interviews are presented directly alongside the quantitative results to provide insight into the changes that occurred. Higher-level themes from the qualitative data are presented at the end of the section, illustrating the underlying dynamics of impacts.

Participant characteristics

Survey

A total of 333 participants completed the telephone-based survey administered during the COVID-19 pandemic; all of whom had previously taken part in the CLEAN-Air(Africa) rapid survey (phase 1) and the majority (279) the previous in-depth survey. Survey participants had a mean age of 39 years, and the majority were female (83 %; N = 275), having been previously selected as the main cook (81 %; N = 269). Households had a mean size of 6.4, generally with three adult residents and three children, the majority living in households with three (27 %; N = 91) or four rooms (26 %; N = 87) (Table 1). Compared with the previous survey, household characteristics generally remained similar, with a slight increase in participant age, presumably due to time between survey periods, and increased number of children under 5 years of age.

Table 1
Demographics of households that took part in surveys before and during COVID-19.

Characteristic		Before (n = 331)[a]	During (n = 333)
Age (mean (SD))		36.2 (13.1)	38.6 (12.07)
Gender	Male	30 (9.1 %)	58 (17.4 %)
	Female	301 (90.9 %)	275 (82.6 %)
Main cook (=yes)	316 (95.5 %)	269 (80.7 %)	
Occupation (head of household)	Day laborer	21 (63.4 %)	Not recorded
	Tradesperson	27 (81.6 %)	
	Business/government employee	98 (29.6 %)	
	Business owner	75 (22.7 %)	
	Farmer	7 (2.1 %)	
	Homemaker	34 (10.3 %)	
	Unemployed	18 (5.4 %)	
	Retired	26 (7.9 %)	
	Other	25 (7.6 %)	
Number of rooms[b]	1	23 (8.3 %)	16 (4.8 %)
	2	50 (15.1 %)	55 (16.5 %)
	3	78 (23.6 %)	91 (27.3 %)
	4	80 (24.2 %)	87 (26.1 %)
	5	37 (11.2 %)	55 (16.5 %)
	6+	9 (2.7 %)	29 (87.0 %)
Household size	All	Not recorded	6.4 (3.3)
	Adults (mean (SD))	Not recorded	2.9 (1.7)
	Number of children (mean (SD))	1.1 (1.1)	3.4 (2.4)

[a] Two households could not be matched between phases.
[b] n = 277 before COVID-19, as number of rooms not recording during the rapid survey (phase 1).

Semi-structured interviews

Interviewees were aged between 24 and 61 years (mean: 38 years). Ten out of 12 interviewees were the primary cook. Eleven were female and one male, reflecting traditional gender norms for cooking at home. Participants' households comprised between 1 and 10 adults (mean: 3 adults) and 1 and 8 children (mean: 3 children) living in 2 to 6 rooms (mean: 4 rooms) (Table 2).

Impacts on household circumstances, food security and cooking practices

The impacts of COVID-19 on livelihoods, food consumption and cooking activities were wide-ranging and included changes to household size and composition, income and food security (Table 3). Most participants (83 %; N = 275) reported the pandemic had lowered their household income; of whom 15 % (N = 42) had no money coming in, 38 % (N = 105) less and not enough money and 45 % (N = 123) less but enough money. Changes in income were due to reduced economic activity and trading opportunities brought about by the pandemic and the accompanying public health restrictions on movement and large gatherings. This was particularly notable for those in informal jobs, such as food vendors selling from roadside stalls:

> "*…it was difficult because I work in the catering field but during that period, clients were no longer coming to eat on the road because gathering [together in large groups] was forbidden.*"
>
> [(Female, aged 39 years, main cook, primary LPG user)]

The number of household residents changed in nearly one third of homes during the pandemic (32.7 %; N = 109). Among these households, 60 % (N = 67) had increased in size and a sizeable proportion (N = 42, 37.8 %) had decreased. The majority of participants (70 %; N = 231) were spending more time indoors, just 2 % (N = 7) less time at home and 29 % (N = 95) reported no change. Changes in time-activity patterns were due to children being out of school, lack of work and a decision to reduce the number of visits to markets or public places to minimise risk of exposure to COVID-19:

> "*…so there were no longer too many outings … so you just needed to do what you had to do and go back home. You don't seek to be where … it's crowded.*"
>
> [(Female, aged 42 years, main cook, primary LPG user)]

More than half (56 %; N = 187) reported having insufficient food. Among these participants, nearly all attributed the cause of their food security to be insufficient money (96 %; N = 180); having to provide for others (16 %; N = 30), unavailability of food for purchase (13 %; N = 25) and more people living at home (8 %; N = 14) were other factors reported by participants. One quarter (25 %; N = 84) had changed the location of their food purchases. Nearly half (49 %; N = 162) had altered the frequency with which they cooked, with the majority cooking much less frequently (77 %, N = 125), but a proportion cooking more frequently (23 %, N = 37). Reasons given for cooking less included households reducing meals to two per day (from three) or cooking large quantities every 3 to 4 days for reheating. Over one-fifth of participants (22 %, N = 73) were cooking for different numbers or combinations of people, with over half cooking for more – largely due to household members remaining home. Changes to the content of cooked meals

Table 2
Characteristics of interviewed participants (N = 12).

Characteristic		#/range (mean)
Female: male		11:1
Age range (years)		24–61 (37.75)
Primary cook		10
Household size	Adults	1–10 (3.17)
	Children	1–8 (3.42)
Number of rooms		2–6 (4.08)

Table 3
Impacts of COVID-19 measures on household circumstances, food consumption and cooking practices (N = 333).

Changes/impacts	N (%)
# residents at home changed (=yes)	109 (32.7 %)
- Less people	42 (38.5 %)
- More	67 (61.5 %)
Income affected (=yes)	270 (81.1 %)
- No money coming in	42 (15.6 %)
- Less money (but enough)	123 (45.6 %)
- Less money (not enough)	105 (38.8 %)
Location of food purchase changed (=yes)	84 (25.2 %)
Enough food (=no)	187 (56.2 %)
- Not enough money	180 (96.3 %)
- Not enough available to buy	25 (13.4 %)
- Have to provide for others	30 (16.0 %)
- More people in the household	14 (7.5 %)
- Cannot travel to the shop	1 (0.5 %)
Time indoors changed	
- More time indoors	231 (69.4 %)
- Less time indoors	7 (2.1 %)
- Remained the same	95 (28.5 %)
Cooking frequency changed (=yes)	162 (48.6 %)
- Much less frequent cooking	29 (17.9 %)
- Less frequent cooking	96 (59.3 %)
- More frequent cooking	37 (22.8 %)
# people cooked for changed (=yes)	73 (21.9 %)
- Cook for more people	46 (63.0 %)
- Cook for less people	27 (37.0 %)
Types of food cooked changed (=yes)	130 (39.0 %)
- More meat/fish	12 (9.2 %)
- Less meat/fish	77 (59.2 %)
- More vegetables	55 (42.3 %)
- Less vegetables	46 (35.4 %)
- More cassava	44 (33.8 %)
- Less cassava	41 (31.5 %)
- More plantain/banana	13 (10 %)
- Less plantain/banana	(38.5 %)
Cooking location changed (=yes)	12 (3.6 %)
Person that cooks changed (=yes)	3 (0.9 %)

were reported in 39 % (N = 130) of households, most commonly involving reduction of meat and increased vegetable consumption. A small proportion had changed their cooking location at home, moving between cooking in indoor kitchens in a communal area or separate room, a covered veranda or outdoor kitchen (4 %, N = 12).

Impacts of the COVID-19 pandemic on cooking fuel consumption and choice

Nearly half (45 %; N = 151) of participants were using LPG as their primary fuel, 40 % (N = 133) wood and the remainder either sawdust (8 %; N = 27), kerosene (2 %; N = 8), unprocessed charcoal (2 %; N = 7) or woodchips (1 %; N = 5) (Table 3). The majority of participants (83 %, N = 276) had been using their primary fuel for more than two years. The COVID-19 pandemic led a small proportion of households to obtain fuel by different means (5 %; N = 15) and some (17 %; N = 56) had experienced changes to fuel costs (Table 4).

Forty-two (13 %) participants had switched their primary cooking fuel due to the impact of the COVID-19 pandemic. The principal reasons given for primary fuel switching were income (50 %; N = 21), followed by saving money (38 %, N = 16) and cooking for more people (12 %; N = 5) (Table 4). Among primary fuel switching households, half (50 %; N = 21) switched towards LPG away from polluting fuels (wood [N = 14], kerosene [N = 3], unprocessed charcoal [N = 3] and sawdust [N = 1]) and 36 % (N = 15) switched away from LPG (to wood [N = 12], sawdust [N = 2], and unprocessed charcoal [N = 1]). Other households switched between polluting fuels (wood, sawdust and unprocessed charcoal). For households switching to polluting fuels, having no income was a dominant reason, while for households switching to LPG, saving money, and cooking more frequently were important reasons. Interviewees who had switched mentioned tending to cook large meals every 3 to 4 days then reheating food most commonly using LPG.

Table 4
Cooking fuel used and changes during COVID-19 pandemic.

Characteristic		Frequency (%)
Primary fuel use (N = 333)		
Primary fuel	Cooking gas/LPG	151 (45.3 %)
	Wood	133 (39.9 %)
	Sawdust	27 (8.1 %)
	Kerosene	8 (2.4 %)
	Charcoal unprocessed	7 (2.1 %)
	Woodchips	5 (1.5 %)
	Other	2 (0.6 %)
Length of primary fuel	More than 2 years	276 (82.8 %)
	1–2 years	27 (8.1 %)
	More than 6 months but <1 year	10 (3.0 %)
	5–6 months	8 (2.4 %)
	3–4 months	9 (2.7 %)
	1–2 months	3 (0.9 %)
	Less than 1 month	–
Changes in primary fuel use		
- Fuel switching		42 (12.6 %)
- Away from LPG		15 (4.5 %)
- To LPG		21(6.3 %)
- Change in how fuel is obtained		15 (4.5 %)
- Change in fuel costs		56 (16.8 %)
LPG using households (N = 242)		
Change in LPG consumption		
- No change		106 (43.8 %)
- Cut down on LPG usage		63 (26.0 %)
- Stopped using LPG		37 (15.2 %)
- Increased usage of LPG		36 (14.8 %)
Reasons for stopping/decreased LPG use (N = 100) [could select multiple reasons]		
- Can't afford it/reduced income		93 (93.0 %)
- Other		17 (17.0 %)
- No longer available		2 (2.0 %)
- Unable to go out to obtain it		0
Reasons for increased LPG use (N = 36) [could select multiple reasons]		
- Cooking more frequently		15 (41.7 %)
- More efficient/faster cooking time		10 (27.8 %)
- Ease of access		7 (19.4 %)
- Cook for more people		6 (16.7 %)
- Heating water/reheating food		6 (16.7 %)
- Ease of access		7 (19.4 %)
- Other		1 (2.8 %)

Among all LPG-using households (either as a primary or secondary fuel) (N = 242), 56 % (N = 136) reported changes in LPG consumption due to COVID-19; 26 % (N = 63) had cut down on LPG use, 15 % (N = 37) had stopped altogether, while 15 % (N = 36) had increased use and the remaining 44 % (N = 106) had no change in use. The main reason for decreasing LPG consumption was reduced income (93 %; N = 93). Reasons for increasing LPG use included cooking more frequently (42 %; N = 15), faster cooking time (19 %; N = 7), cooking for more people (17 %; N = 6) and heating water/reheating food (17 %; N = 6).

Complex dynamics of maintaining food and fuel access during COVID-19

In the following section, we present high-level themes describing the overarching dynamics impacting fuel and food access during the pandemic.

Local systems support resilience

The pandemic has forced a return to reliance on local systems. As supply chains were disrupted due to border closures that prevented the free movement of goods between counties, households had to depend more heavily on local food and fuel sources. Certain foods, such as tomatoes, condiments, and spices were no longer available, or were more difficult to access at local markets. As a result, the price of some food items increased and households adapted their menus towards

foods that remained inexpensive, such as rice. Having a farm or small plot of land helped some households maintain their food supply by harvesting staples such as cassava, maize, and palm fruits for oil:

> "*But as the food was not enough, I took the rest from the farm. I look for cassava, maize, groundnuts in the farm.*"
> [(Female, aged 55 years, main cook, primary wood user)]

There were numerous examples of households sourcing food from members of the local community or a nearby village. Examples included purchasing corn doughnuts ('puff-puff') cooked by a neighbour to replace school meals as classes had been suspended, or arranging to collect food from the village enroute to market. Fuel distribution was similarly affected by the pandemic. LPG (known as 'cooking gas') was more difficult to obtain as stores closed or had limited stock and shortages led to long queues. Easy access to firewood from neighbours or farms supported some households to maintain use of, or to switch to, firewood as cooking fuel.

Households respond through multiple coping mechanisms

Households employed a wide range of strategies to overcome difficulties related to food access and availability. To maintain food access, households reduced trips to the market by stocking up monthly in bulk, sought out other local sources and adapted menus to include foods that remained affordable and available. Some participants cited social distancing rules, time spent queuing and the risk of infection as reasons for reducing trips to the market. Reducing the frequency of food intake, in particular eating two meals (mid-morning and mid-afternoon) instead of three (breakfast, lunch, and dinner) was a common strategy to minimise hunger due to food shortages. Other tactics included reducing the portion size of meals, adding supplements or water to make food go further and adults going without food to ensure that children had enough to eat. Cooking frequency (cooking daily or not) depended on income, with some households deciding to cook a large quantity once every 3–4 days then making the food last and reheating portions when needed. Overall, however, compared with before the pandemic, the quantity of food cooked at home had increased, as children were unable to eat meals at school.

Fuel choice and consumption nuanced by cooking practices

The dynamic between cooking practices and fuel choice/consumption altered and became more finely balanced during the pandemic. A large majority of households were cooking less frequently, yet a majority were also cooking more food for more people. In response, households appeared to be more conscientious in choosing fuels to suit the foodstuff cooked or the task in hand, making frequent, minor adaptations to save money. LPG was preferred for smaller tasks, such as reheating leftovers, heating babies' milk and preparing simple dishes, while firewood was preferred for more complex (traditional) dishes:

> "*...my gas [LPG] is there to heat the food, or maybe I can have a little thing I want to make like porridge, or fried rice, the quick one.*"
> [(Female, aged 28 years, main cook, primary wood user)]

As households cooked less frequently and in bulk, LPG use became more prominent in some households to reheat meals:

> "*I have noticed that my gas got finished a little bit faster than before… If you start warming a meal every time someone has to eat, if you don't have microwave you need to warm and warm again and again. This takes you too much of gas fuel.*"
> [(Female, aged 39 years, main cook, primary LPG user)]

Overall, however, cooking more food at home increased households' fuel consumption of both LPG and firewood, as households ate at home more (rather than eating out) and many cooked for more people.

Discussion

This study highlighted how households in peri-urban Mbalmayo experienced considerable change and disruption to their household structure and living situation because of the COVID-19 pandemic and public health measures, reflecting the national picture and experiences elsewhere in Africa and worldwide (Sovacool, Furszyfer Del Rio, & Griffiths, 2020). Most participants and their families spent more time at home during COVID-19 restrictions. Changes to household income were widely reported, with several households losing their typical income streams. It is important to consider that in Cameroon about 90 % of jobs are in the informal economy (NIS, 2005, 2011) and underemployment is widespread (Ehode Elah & Tourere, 2020). Our findings highlight the vulnerability of workers in the informal sector during a financial crisis. The restrictions led to some businesses such as road-side food vendors to cease trading, as the public were banned from gathering to reduce risks of exposure to COVID-19. Economic activity in Cameroon declined substantially during 2020; consumption fell in response to loss of household and business income, and public and private investment stalled (World Bank, 2021).

At the height of Government restrictions – the lockdown period just before study initiation – schools were closed, meaning children nationally were required to remain home and thus there were more mouths to feed during the day. School closures placed an extra burden on households to provide food, which would have otherwise been provided elsewhere. This, combined with reduced household income, increased food prices and restricted access to regular food sources, led to widespread food insecurity in the study population. The adaptations to diet, food consumption, purchasing and preparation, which Cameroonian study participants described, are characteristic of food insecure populations in high income settings (Cook et al., 2008). In the USA for example, parents describe skipping a meal to prioritize feeding their children, reducing portion sizes, and modifying their diet towards cheaper locally available food, such as carbohydrates. Study participants described a common practice known as 'watering down the soup', to make a meal stretch further to accommodate more people. Changing food shopping habits is also typical of food insecure populations. Fear of infection and restrictions on movement brought about by the pandemic had added an additional layer of complexity, and participants described shopping less frequently to avoid infection and restricting their shopping to one or two less crowded locations.

The increase in food insecurity experienced by our study population is likely to have been replicated across the country, particularly in the northern regions (including the North-West and Far North, where poverty is more concentrated) and will have been exacerbated by the rise in global food prices. Along with the South-West region, the northern regions have been heavily affected by internal conflict since 2017 (World Bank, 2021). Although the percentage of the Cameroon population living in poverty in has decreased, the reduction rate has been outpaced by population growth. Accordingly, the absolute number living in poverty increased by 12 % to 8.1 million between 2007 and 2014 (NIS, 2015). Moreover, income disparities have grown between the rural population (where the prevalence of poverty has increased) and the urban population (in which poverty has decreased) and between the highest and lowest income quartiles (NIS, 2015). The pandemic is estimated to have led to an increase in the rate of extreme poverty from 24.5 % in 2019 to 25.3 % in 2021 (World Bank, 2021). In our study, households owning or renting a farm, or having a small plot of land were somewhat protected from rising food prices, food shortages, a reduction in income and the complications of obtaining food under travel restrictions, as they could harvest produce from their land.

A substantial proportion (41 %) of LPG users (N = 242) in our survey had cut down on or ceased using LPG entirely. At the same time, among the 12 % of participants switching their primary cooking fuel, more households switched to LPG (6 %) as a primary fuel than from LPG to polluting fuels (5 %). The proportion of households switching away

from LPG is lower than reported in an informal urban settlement in Kenya where 27 % of households switched away from LPG to polluting primary cooking fuels. This suggests that changes in fuel choice in a peri-urban setting were a complex function of fuel access, household income (including recourse to alternative income, food and fuel sources), and the cooking task at hand – with households tending to use LPG for simple tasks such as reheating food, highlighting how different fuels are used to respond to different cooking needs. In addition, cooking in bulk, and then storing and reheating food later highlights the need for a cold supply chain to appropriately store food, such as in refrigerators, to maintain food hygiene and avoid food-borne diseases. Our findings add further nuance to our understanding of the interdependencies between fuel and food (Shupler et al., 2021) and the well-established water, energy, food nexus – WEF (Green et al., 2017; Molajou et al., 2021). Our study strengthens the urgency of creating resilient energy and food systems which are resistant to shocks (such as natural disasters, humanitarian emergencies, economic crises and epidemics) and to protect the most vulnerable to maintain clean fuel and food access and gains made towards the SDGs.

Limitations

Our study was positively skewed towards households using LPG as a primary fuel (45.3 %), compared with national levels (~25 %), as our study involved stratified random sampling by primary fuel type to select 50 % primary LPG users. While unable to make generalisations at a population level, this analysis uncovered strategies families employed to sustain clean cooking in a time of national economic crisis. Impacts of the pandemic likely differed in urban and rural contexts, with changes dependant on household income, accessibility of goods, and ability to social distance. Further to this, due to changes in phone numbers and participants not being reachable by mobile, we had 105 refusals or non-contactable participants. This may have skewed our study to those who remained in Mbalmayo during the pandemic or were less affected by restrictions.

Recruitment and interviewing by remote methods during the turbulence of a pandemic was challenging, which may have affected data quality. Efforts were made to verify the data through reviewing responses with the field team responsible for data collection. Furthermore, while impacts were self-reported by households, the data provides empirical evidence on the far-reaching effects of the pandemic, which were reinforced through the SSIs.

Conclusions

Our work has highlighted the substantial impact of the COVID-19 pandemic and complex dynamics in individuals' ability to maintain sufficient food intake for their family while sustaining clean cooking. Reductions in households' income resulted in substantial changes to the amount, frequency and types of food cooked. While households employed a range of strategies in response to changes in food access, we found strong evidence of food insecurity across the study population. Impacts on fuel use were more complex, with changes in fuel use linked to changes in cooking practices as a result of the pandemic. Enhanced understanding of cooking practices and how they informs fuel choice and use, would aid the development of solutions for exclusive clean cooking. Local systems helped to maintain food intake and fuel access; where food and fuels were locally available, households were able to sustain use throughout COVID-19 lockdowns. These findings highlight the importance of clean cooking services being locally responsive and easily accessible to all.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. In-depth survey – sample size calculation and sampling approach

Sample size calculation

The in-depth survey sample size was based on the blood pressure measurements to be recorded concurrently with the in-depth survey. The sample size was targeted to have sufficient power to detect a difference in systolic and diastolic blood pressure between fuel using groups (LPG versus polluting fuels). The details of the calculation to achieve an adequate sample size are outlined below.

The following formula was used to calculate the sample size:

$$N = (Z\alpha/2 + Z\beta)^2 * 2 * \sigma^2 / d^2$$

where,

N = sample size
$Z\alpha / 2$ = z-score associated with confidence level. Typical value is 1.96 for 95 % confidence (alpha = 0.05)
$Z\beta$ = z-score associated with statistical power. Typical value is 0.84 for 80 % power
σ = is the standard deviation of the outcome in the population
d = is the difference between two groups you want to detect.

Using an exposure-response relationship between systolic blood pressure (SBP) and $PM_{2.5}$ (Fig. A1), the expected cross-sectional difference in systolic blood pressure between wood and LPG users can be estimated. While the relationship in Fig. A1 was mapped for a different demographic (138 women in rural China > age 50), it is noted that the relationship between $PM_{2.5}$ and blood pressure has held in other settings, with several studies showing a difference in SBP between solid fuels and clean fuels of 1.5–7 mm Hg (Arku et al., 2018).

With an estimated $PM_{2.5}$ exposure of 270 μg/m^3 for wood users and 70 μg/m^3 for LPG users, a difference in SBP of 6 mm Hg is estimated between wood and LPG users (Fig. A1; 131 vs 125 mm Hg, respectively).

$$N = (1.96 + 0.84)^2 * 2 * (6\text{ mm Hg})^2 / (16\text{ mm Hg})^2 = 111.5 \text{ participants per study arm}$$

The estimated sample size needed to achieve 80 % power, 5 % significance, with a standard deviation of 16 mm Hg for SBP in Ghana (Arku et al., 2018) is 112.

Accounting for an additional buffer of 40 % to account for potential increased variability in blood pressure in our sample, the estimated sample size is

$$112/(1 - 0.4) = 186.67 = 187$$

In summary, a sample size of approximately 190 in each group (total: 380) is required for the ability to detect a difference in blood pressure outcomes between fuel groups. We will sample 200 in each fuel group (400 total).

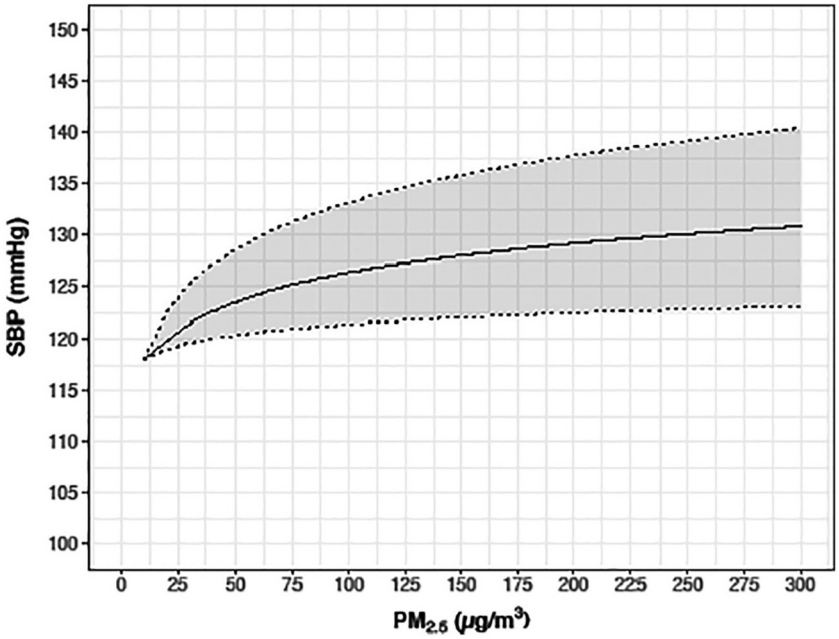

Fig. A1. Exposure-response relationship for systolic blood pressure in women.
(From Baumgartner et al. (2011).)

Stratified random sampling

Stratified random sampling was used to select approximately 225 households primarily cooking with LPG and 225 households exclusively cooking with biomass (as identified in the Rapid Survey) to account for potential loss to follow up between survey rounds. We thus provided the field team with a list of 450 total participants; the team conducted a total of 38 surveys above the 400-person target (n = 438) as they ran a couple days ahead of schedule and there was minimal loss to follow up.

All participants lived within Mbalmayo (we did not consider small administrative units in our sampling strategy). Stratified random sampling was done with respect to cooking fuel type.

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