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Using a food-energy nexus lens to explore people's experiences of the cooking journey in African informal settlements

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ABSTRACT

Solid fuels are still used by over 3 billion people worldwide, including many residents of informal settlements. Most interventions designed to improve people's solid fuel-related health have failed or fallen short of their ambitions. Often, this is because implementers have not fully understood the contexts, cultures and behaviours of the places and people they are working within and with. To address this, our study used a food-energy nexus lens to explore people's experiences of the cooking journey, i.e., decision-making regarding which fuel to use, obtaining fuel and then cooking using that fuel. We videoed 'go along' interviews with residents of two African informal settlements during their cooking journeys. Interviews with 15 participants in Mukuru (Kenya) and 15 in Ndirande (Malawi) were analyzed using thematic analysis. Participants' decision-making regarding fuel use was complex, dynamic (considering short-to-long timescales) and context-specific. Participants were aware of some of the household air pollution (and other solid fuel-related) health risks, though there were some misconceptions. The use of waste materials in solid fuel cooking – particularly during ignition – was common. The 'cooking journey' framing in this study highlighted the range of risks and challenges experienced across the food-energy nexus beyond household air pollution, including terrain, the built environment and gender-based violence. Broader approaches to understanding the contexts, cultures and behaviours of fuel users in informal settlements, such as our 'cooking journey' approach, can support better intervention design, and therefore enable progress towards sustainable development goal 7 - access to affordable, reliable, sustainable and modern energy for all.

Introduction

Globally, almost 3.6 billion people still rely on solid fuels, such as wood, charcoal, animal dung and crop waste, to meet their cooking needs (Health Effects Institute, 2024). The household air pollution (HAP) generated through cooking with these fuels contributes to 3.2 million premature deaths every year (World Health Organisation, 2024). In 2021, the region with the highest percentage of the population exposed to solid cooking fuels was sub-Saharan Africa (79 %), followed by south Asia (53 %), southeast Asia, east Asia and Oceania (29 %) (Bennitt et al., 2025). Exposure to HAP in Africa caused 700,000 premature deaths in 2019 (Fisher et al., 2021). HAP is linked to non-communicable diseases including stroke, ischemic heart disease, chronic obstructive pulmonary disease, and lung cancer (Alemayohu et al., 2023; Bennitt, Wozniak, Causey, Burkart, & Brauer, 2021; Boutros et al., 2024; Lee et al., 2020; Zhou et al., 2024). Cooking using solid fuels can also lead to other health impacts, such as burns and exposure to gender-based violence during fuel collection (Adnan, Soomar, Nafees,

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Aftab, & Fatmi, 2025; Ho et al., 2021; Puthumana et al., 2021). Beyond the significant health impacts, solid fuel use can also place significant burdens on people through the collection of fuel and longer cooking times, reducing the time available for other tasks including education (Shupler et al., 2021). High rates of solid fuel use in sub-Saharan Africa are set to persist in the coming years (Stoner et al., 2021), contrasting with the ambitions of United Nations Sustainable Development Goal (SDG) 7.1; by 2030, ensure universal access to affordable, reliable and modern energy services.

In 2022 low-income urban areas (or informal settlements) were home to 23 % of urban residents globally and 54 % of urban residents in sub-Saharan Africa (UN-Habitat, 2025). Informal settlements are often characterized by overcrowding, substandard housing, poor environmental conditions, unemployment, lack of basic amenities (including health facilities and transport), insecurity and poverty (Alaazi & Aganah, 2020; Dovey, van Oostrum, Shafique, Chatterjee, & Pafka, 2023; Weaver, Richmond, & Pegues, 2023). However, informal settlements are not homogeneous, either within a single country or between countries (Dovey et al., 2023). Understanding these similarities and differences are important for exploring the diversity of people's experiences and designing effective interventions.

Residents of informal settlements often struggle to access safe and reliable energy, due to issues with availability and cost (Corburn & Sverdlik, 2019; Uny et al., 2024). There are also more 'hidden' socio-cultural factors which impact household fuel decision-making (McCarron et al., 2020). Household fuel decision-making is complex and dynamic. The type of fuel a household uses may change by season (Gould et al., 2022; Phillip et al., 2025), and according to the types of foods being cooked (Uny et al., 2024). There is also evidence that 'stove stacking', i.e., reliance on multiple energy types to meet household needs, is common (Dumga & Goswami, 2023; Jewitt, Atagher, & Clifford, 2020; Ochieng, Zhang, Nyabwa, Otieno, & Spillane, 2020).

To reduce exposure to HAP from solid fuels, options include using the same fuel but modifying the exposures by using improved cookstoves, ventilation and/or chimneys, or moving to cleaner fuels (e.g., liquefied petroleum gas (LPG), ethanol or electricity). However, overall, HAP interventions (particularly at the household level) have had limited success to date (Bennitt et al., 2025; Quansah et al., 2017), particularly in terms of health benefits. Often this is because the intervention has adopted a top-down and/or technocratic approach, e.g., providing households with an improved cookstove that does not fully consider the household's needs, cooking styles, culture and other contextual factors (McCarron et al., 2020). For example, in a study aiming to understand why improved cookstove interventions have often failed in India, Khandelwal et al. (2017) outlined how the interventions required significant cultural and behavioral changes which meant adoption rates were generally low and drop off in usage over time was high. Consequently, further research is needed to better understand how to design more effective solid fuel-related interventions.

Previous work by Shupler et al. (2021) has highlighted the complex relationships that exist between household demographics, finances, diet and cooking patterns (specifically in their case in the context of the COVID-19 lockdown), emphasizing the links between food and fuel use and advocating for food-energy nexus research approaches. In the context of cooking with solid fuels, this approach examines how the availability of fuels and household energy choices affect food preparation, nutrition, and broader food system outcomes. The food-energy nexus approach forms part of what Wright, Sathre, and Buluswar (2020) call in their review the 'cooking system', which is described as a complex, interconnected web that extends far beyond stoves. It includes the type of fuel(s) used, how it is sourced and distributed, and the cultural and behavioral practices of users. Broader financial structures, infrastructure access, and policy environments also shape the system (Uny et al., 2024). Other work (e.g., McCarron et al., 2020; Phillip et al., 2023) has evidenced the need for HAP intervention research that centers people's experiences. In particular, a key recommendation from Jewitt et al. (2020), was that more emphasis on risk perception is needed to help yield further insights into fuel use and decision-making, particularly by exploring which risks people bring to the foreground and which remain in the background.

Taken together, past research has highlighted the importance of taking a broader view to understanding which fuels people use for cooking within their own cooking systems and why, as the basis for the design of interventions (McCarron et al., 2020; Uny et al., 2024; Wright et al., 2020). Therefore, in this study we adopt a food-energy nexus lens and focus on the cooking journey from 'fuel to pot'. The cooking journey, as we define it in this paper, encompasses the decision-making regarding which fuel to use, the journey made to obtain that fuel and then the cooking of food at home using that fuel. Using the framing of the journey to explore socio-environmental issues in informal settlements has been used successfully in past work (see, for example, Adams et al. (2022), for the case of water fetching), though not to our knowledge for cooking journeys. The aim of our exploratory study was to explore people's experiences of cooking in African informal settlements from the point of obtaining the fuel to cooking and serving a meal. In doing so, our specific objectives were to: 1) better understand the decision-making processes determining which fuels were collected or purchased, 2) identify some of the key risks and challenges faced during fuel collection or purchase, and 3) explore people's experiences of cooking using the obtained fuels. We do this using 'go-along' interviews in two informal settlement case studies; Mukuru in Nairobi, Kenya, and Ndirande in Blantyre, Malawi.

Methods

The data used in this paper is part of a wider exploratory study – the 'Fuel to Pot' study, which aimed to better understand the cultures, behaviours and experiences of those who rely on wood, charcoal and animal dung for their cooking needs in informal settlements (see also, Uny et al. (2024)). The 'Fuel to Pot' study, focused on informal settlements in two African countries, Malawi and Kenya, since these two countries offer contrasting energy system contexts. Kenya is a leader in sub-Saharan Africa in terms of its climate and renewable energy policies (Apergi et al., 2024) and is making good progress towards widespread clean fuel use, with 76 % of the population having access to electricity in 2023 (World Bank, 2025). In contrast, the transition to sustainable and clean energy sources in Malawi is going much more slowly, with only 16 % of the population having access to electricity in 2023 (World Bank, 2025). These country-level energy system contrasts frame the specific informal settlements of focus in this work (Mukuru in Kenya and Ndirande in Malawi).

This section outlines the two study areas of focus in this study, how participants were selected, how the 'go-along' interviews were undertaken and how the collected data were analyzed. Ethical approval was obtained for this study from the University of Stirling (GUEP 1828), the National Committee on Research in the Social Sciences and Humanities in Malawi (NO. P.11/21/607) and the Kenya Medical Research Institute (KEMRI/SERU/CRDR/067/4350).

Study areas

The study was undertaken in two informal settlements; Ndirande in Blantyre, Malawi, and Mukuru in Nairobi, Kenya, with the intention of better understanding the diversity of human experiences within and between informal settlements.

Ndirande is a large informal settlement in the urban area of Blantyre, in the Southern region of Malawi. Dwellings in Ndirande vary in size and make (e.g., fired and unfired bricks, wooden panels and/or corrugated iron sheets). In addition to housing challenges, the settlement is also characterized by limited access to water and sanitation facilities and municipal services like roads, electricity and refuse collection. In Malawi over 95 % of households use wood or charcoal as their main cooking fuel

(Government of Malawi National Statistics Office, 2018). This is exemplified in Ndirande, where use of solid fuels, including wood, charcoal and charcoal briquettes (balls formed from leftover charcoal, soil and water and dried in the sun), is near-universal (Uny et al., 2024).

In Kenya an estimated 41 % of the urban population lived in informal settlements in 2022 (UN-Habitat, 2024). One of the largest informal settlements in Kenya is Mukuru, located east of Nairobi's center. Mukuru is home to an estimated 100,000 households with a housing density of around 240 homes per acre (Corburn et al., 2017). Mukuru residents survive on low incomes and unemployment rates are high. Houses generally consist of 3 m × 3 m structures made of corrugated metal and wood (Corburn, Njoroge, Weru, & Musya, 2022). Between these houses is a network of paths and unpaved roads, intertwined with drainage channels. In addition to housing, access to other basic services such as sanitation systems and clean water are lacking (Ouma, Njoroge, & Weru, 2025). To address this, Mukuru was designated a Special Planning Area (SPA) by Nairobi City County Government in 2017, triggering a participatory upgrading process. Available cooking fuels in Mukuru include wood, charcoal, LPG, kerosene and electricity (Uny et al., 2024).

Selection of participants

As is customary to facilitate community engagement with research in Africa (Bain et al., 2022), prior to recruitment, the researchers held entry and sensitization community meetings in Mukuru and Ndirande with traditional leaders. At these meetings, the study was presented so that the residents could ask questions. Thereafter, residents interested in participating came forward (~30 per settlement) and were screened according to our selection criteria: over 16 years of age; responsible for obtaining fuel and cooking in the home; physically able to collect fuel; residing in the area for at least 6 months; residing in a home within walking distance to where they collect/purchase fuel. We also aimed to include people of all ages from various areas of the settlements in our sample.

Data collection

We used 'go along' interviews (sometimes also called walking interviews) to explore people's experiences of cooking in African informal settlements from the point of obtaining the cooking fuel to serving a meal. The use of walking interviews (or 'go-along' interviews) has become more common in geographic research in recent years (Di Masso et al., 2025; Evans & Jones, 2011; Pierce & Lawhon, 2015), however to our knowledge this is the first time they have been used to understand fuel collection and cooking. Walking interviews have been used in a very similar settlement to Ndirande in peri-urban Blantyre (Malawi) in recent years to better understand water fetching (Adams et al., 2022), evidencing their use previously in informal settlement contexts.

In our study we use the term 'go-along' interview, since the researcher accompanied the participant during their journey to obtain fuel (i.e., walking) and then stayed with them while they cooked using that fuel once they returned home (i.e., static). The use of 'go-along' interviews enabled the researchers to experience the cooking journey with the participant in real-time, enabling in-depth and dynamic place-based discussion. Such an approach helps elicit rich, contextual data and has been deemed particularly relevant to research with marginalized groups (Bartlett, Koncul, Lid, George, & Haugen, 2023), such as those living in informal settlements.

The 'go-along' interviews were conducted in July and August 2022 in both Ndirande and Mukuru (the dry seasons). The researchers undertaking the interviews (TC and MN) were fluent in both English and the local languages (Chichewa in Ndirande and Swahili in Mukuru). Participants were asked to undertake their activities as normal, i.e., to collect or purchase the fuel they normally would and to cook whatever they would normally be cooking anyway. We used a semi-structured topic guide to structure the interviews. Part one of the interview included questions focused on demographics and community to contextualize the participant's experiences with solid fuel use and cooking practices. Part two was focused on fuel collection, including materials used, reasons for choosing those materials, the costs, time spent, and any difficulties or health risks associated with the fuel. Part three of the interview focused on the cooking process. The researchers observed firsthand how the participant used the fuels to prepare food and asked specific questions about fuel use and health risks. During the walks, the participant's journey was filmed using a GoPro HERO10 to record audio for transcription and to record video.

Data analysis

The interviews were transcribed and translated to English. The transcripts were anonymized and uploaded to NVivo 12 to support the analysis. A codebook was developed by authors IU, LC, TC and MN, and then piloted on a sample of interviews and refined by the team. The remainder of the interviews were coded by authors TC and MN using the finalized codebook. We used a thematic analysis to analyze the interviews, where researchers familiarized themselves with the data through close reading of transcripts, coded the data, generated broad themes, refined and discussed the themes and thereafter wrote up the results. To increase inter-coder reliability and to ensure deep familiarity with the data, the whole team of researchers was collaboratively involved in the summarizing and analysis of the coded data. The analytical summaries were collated by IU and further discussed by the team in several meetings. Our themes and subthemes were further mapped looking for links between themes, further analyzed and grouped into higher order categories by authors HP, LK, TC and FO, and the results written from this. A project reflexivity statement is given in Uny et al. (2024). In brief, and in relation to the research presented here, while our teams included researchers in Malawi and Kenya, all researchers were still – in some ways – outsiders compared to our participants in Ndirande and Mukuru. We do not share the everyday experiences of fuel collection and fuel use as our participants. We recognize that our experiences and ideas will shape the outcomes of the research, so we designed our analytical approach with this in mind. Our reflexive approach to the coding of interview transcripts enabled space for discussion and collaborative analysis.

We present our analysis in terms of the cooking journey (before the cooking journey begins, obtaining fuel, cooking at home). Quotes are included in the text to illustrate key aspects. Key participant information considered helpful context in understanding the quotes is included following each quote (age, gender, where they lived, type of fuel obtained on the journey). The video data were used to support understanding and interpretation of the interviews, and to explore factors of interest such as who was nearby during cooking and what sort of risks and challenges people experienced on the journey to obtain fuel. Stills from the videos are included in the results section to help visualize the context and to exemplify findings.

Results

In total, 30 participants undertook walking interviews, with half of these in Ndirande and half in Mukuru (Table 1). Participants purposively included more women in both settlements as they are often responsible for cooking. On average, participants were younger in Mukuru. All participants in Ndirande collected solid fuels (firewood, charcoal and charcoal briquettes). Fuel use was more mixed in Mukuru with over 50 % of participants reporting using liquid fuels (kerosene, LPG, ethanol).

Cooking journeys

Representative examples of the cooking journeys of residents in Ndirande and Mukuru are shown in Figs. 1 and 2 respectively. The selected examples begin to show the diversity of experiences within and

Table 1
Summary data relating to the walking interviews.

	Ndirande	Mukuru
Number of participants	15	15
Gender		
Male *n* (%)	5 (33.3)	6 (40)
Female *n* (%)	10 (66.7)	9 (60)
Mean age (age range)	34 (16 - 69)	26 (16 - 50)*
Fuel obtained during walk		
Firewood *n* (%)	7 (46.7)	1 (6.7)
Charcoal *n* (%)	6 (40.0)	5 (33.3)
Charcoal briquettes *n* (%)	2 (13.3)	
Kerosene *n* (%)		4 (26.7)
LPG *n* (%)		4 (26.7)
Ethanol *n* (%)		1 (6.7)

* In Mukuru one participant's age was unknown, so here we have calculated the average from 14 participants.

across the two settlements. In Fig. 1, a 39-year-old female resident of Ndirande who scavenges for wood next to the river, spoke of the challenges of collecting firewood rather than having the money to purchase charcoal:

> "*Cooking like this [with firewood] involves always looking around… for charcoal, you just get your plastic bag, go out to the road and do what? Buy your charcoal and go home… it's cooking with freedom. So this [collecting firewood] is cooking with problems"*
>
> *(39-year-old female resident of Ndirande [firewood])*

The photographs show some of the 'problems' the participant describes, evidencing the physical challenges of scavenging firewood. For the 16-year-old resident of Ndirande who was purchasing charcoal (Fig. 1), the journey to the point of fuel purchase takes her past and through a range of built environment challenges, including hanging washing, steep and uneven ground, deep water and requires her to share the path with others (e.g., those on motorbikes). The journeys finish with cooking outside in one case and on the veranda in the other.

In Mukuru, the 19-year-old female resident who was purchasing charcoal (Fig. 2) must navigate a rickety wooden bridge to cross a waste-filled drainage channel to reach a narrow path, and she does so while wearing flip flops and carrying her child. For the 20-year-old male purchasing kerosene, walking down streets covered in waste and navigation of drainage channels are key parts of the journey. Both exemplified journeys finish with cooking inside the home in a dark and enclosed space.

The terrain and built environment present challenges and risks to residents as they obtain fuel in both settlements, regardless of the type of fuel being obtained. Such commonalities within and between the settlements include steep and uneven ground, drainage channels and walking through waste dumps. In both settlements the selected examples also highlight a commonality in terms of children and young people's involvement in the fuel journey and cooking process (Figs. 1 and 2). However, the selected examples also speak to some key differences between the settlements, explored further below, in terms of the location for cooking (Section "Cooking at home") and whether that is indoors or outdoors.

The remainder of this section is organized to follow the flow of the cooking journey to first determine which fuel(s) are needed (Section "Before the cooking journey begins"), people's experiences of collecting or purchasing fuel (Section "Obtaining fuel") and cooking using that fuel (Section "Cooking at home") in both communities.

Before the cooking journey begins

While the available fuel sources varied between Ndirande and Mukuru, the decision-making processes around which fuels to use for cooking (and where to obtain them from) were broadly underpinned by similar factors (Table 2). Key factors (in order of the number of mentions across the two settlements) included the time input required (to get the fuel ready to start cooking, how long the fuel lasts and how much tending is needed during cooking), the cost of fuels, ease of use (including cleanliness and how much input is needed during cooking), the perceived health impacts, the type of food being cooked, availability of the fuel, the weather, tradition, and other people's perceptions (e.g., other household members, wider members of the community) of cooking using that fuel.

While our sample size was small, there were some key differences between the two communities in terms of the factors that were more commonly mentioned. For example, cost was mentioned more frequently in Mukuru than in Ndirande. This may be due to more participants scavenging for fuels (firewood) in Ndirande. In both communities, factors such as time and cost were more frequently mentioned than the health impacts of cooking. It might have been expected for the participants in Ndirande to mention smoke and its associated health impacts more frequently than in Mukuru (due to the greater reliance on solid fuels in Ndirande), however more participants in Mukuru considered health impacts in their decision-making. Within the 'solid fuels' category, some fuels were considered smokier than others and there was also variation in perceived smokiness within a single fuel type (such as wood). The type of food being cooked was more commonly mentioned as a factor influencing fuel choice in Ndirande than Mukuru. In the interviews this difference appeared to relate to how people purchase key foods that take a long time to cook, e.g., beans. In Ndirande, people cook beans from scratch which takes a long time and requires a lot of fuel. In Mukuru, people more commonly purchase pre-cooked beans from street vendors that they reheat, reducing the fuel requirements.

Obtaining fuel

This section considers the choice of where to obtain a particular fuel from and the experience of the journey to obtain that fuel. Notably in both settlements obtaining fuel was something done regularly (e.g., sub-daily, daily) depending on the needs of the household. For those purchasing fuel, purchases were made as and when funds were available, meaning that quantities bought were small. Some participants explained how if there was no money available for fuel, meals were skipped. In deciding which seller to purchase fuel from (or where to collect it from) key factors considered included proximity to home, relationships with the fuel seller, the customer service experience and the fuel quality:

> "[I] like it because it is near, I don't have to go far as is the case sometimes when the seller is away"
>
> (19-year-old male resident of Ndirande [charcoal])

> "Being a regular customer here because sometimes you can be broke and I will come to this shop and borrow"
>
> (20-year-old male resident of Mukuru [kerosene])

In both settlements, sometimes people collected fuel alone and sometimes with others (including friends, their children and other relatives). For some, there were positives in making the journey to collect fuel, particularly as a way to pass the time. However, more commonly for participants, journeys to collect fuel brought challenges and risks (see, for example, Figs. 1 and 2). These included challenges related to the length of the journey and the physical effort of carrying the fuel. Others expressed frustration at the risks encountered when collecting fuel, in comparison with other fuel types that they perceived not to lead to such risks. Particularly in Ndirande, risks to personal safety from violence were highlighted by both younger and older female participants as concerns during fuel collection, particularly at certain times of the day:

> "We travel in groups because it is unsafe because just a while back people were getting killed so we are afraid of getting assaulted"
>
> (23-year-old female resident of Ndirande [briquettes])

Fig. 1. Two representative examples of cooking from 'fuel to pot' in Ndirande. For 1 (39-year-old female resident [firewood]) showing the terrain encountered when walking to collect firewood (1a), the collection of firewood from a river (1b - 1d), establishing the fire by fanning the flame (1e) and children helping their mother tend the fire during cooking (1f). For 2 (16-year-old resident [charcoal]) showing terrain encountered during fuel purchase; washing lines (2a), hilly paths (2b), wells next to the path (2c), shared use bridges (2d), then purchase of charcoal (2e) and cooking on the veranda with a stained wall next to the stove (2f).

Fig. 2. Two representative examples of cooking from 'fuel to pot' in Mukuru. For 1 (19-year-old female resident [charcoal]) showing examples of the terrain encountered during purchase of charcoal (1a and 1b), purchasing charcoal (1c) and cooking inside the home using the purchased charcoal (1d). For 2 (20-year-old male resident [kerosene]) showing examples of the terrain encountered during the purchase of kerosene (2a – 2c) and cooking inside the home with kerosene (2d).

> "Some people can steal the money because these routes are scary"
> (16-year-old female resident of Ndirande [charcoal])

Less commonly, the built environment, mud and a lack of road infrastructure (see also Figs. 1 and 2) were highlighted as challenges when obtaining fuel:

> "I would like that road to be built… There was a day I fell down there in that shortcut [small uneven path] when I was running late at night"
> (20-year-old male resident of Mukuru [kerosene])

Other challenges encountered during fuel collection related to the smells experienced on the route and the presence of animals (such as snakes). Conversely, some of the participants outlined factors which made their journey safer, such as their proximity to the purchase/collection point or their age and/or standing in the community:

> "I have never encountered any problems because a lot of people love me…I laugh with them, granny granny granny like you heard"
> (69-year-old female resident of Ndirande [charcoal])

Cooking at home

This section considers the key factors that were identified in the interviews relating to the cooking process. These were where (in or around the home) people cooked, materials used for solid fuel ignition, people's experiences of cooking, the role of gender and the health impacts of cooking. In terms of the foods which were cooked in the two locations, in

Table 2
Key factors which influenced individual decision-making around cooking fuel type selection. Factors are ordered (top to bottom) by the number of times they were mentioned as factors that influenced decision-making by residents in Ndirande and Mukuru (combined).

Key factor	Ndirande	Mukuru
Time	*"The electrical stove was convenient, you just had to switch it on and start cooking while with charcoal you have to wait for the charcoal to fully light up before you can cook" (19-year-old male [charcoal]).*	*"You see like the jiko [a cookstove that uses charcoal which is common in Kenya] … lighting it is a lot of work…you can't use it while in a hurry" (34-year-old female [LPG]).*
	"Firewood doesn't take time to burn out…now this charcoal, you can cook bonya [small fish], nsima [thick porridge prepared with maize flour] and have some [left] to warm your water" (69-year-old female [charcoal]).	*"This one [LPG] cooks faster [compared to firewood or charcoal], it is not time consuming, you just cook without any problem" (16-year-old female [LPG]).*
Cost	*"There is nothing I like about cooking with firewood, I just use it because of the money that is available" (20-year-old female [charcoal]).*	*"Kerosene is affordable to someone like me" (22-year-old male [kerosene]).*
Ease of use	*"When we use charcoal the pots are not as dirty [compared to firewood]" (39-year-old female [firewood]).*	*"Gas has class, it does not have any smoke, the sufuria [pot] doesn't get dirty" (17-year-old female [kerosene]).*
	"When you light up the charcoal you can leave your food to cook freely but when using firewood you just can't leave what you're cooking on the fire and go" (58-year-old female [charcoal]).	
Health impacts	*"I would prefer electric cooking…smoke sometimes enters in eyes especially when we think of sitting down when cooking [with charcoal]" (16-year-old female [charcoal]).*	*"I love gas [when I can afford it] because sometimes it has no effects" (25-year-old female [firewood]).*
Type of food being cooked	*"When you want to make Thobwa [traditional, non-alcoholic, fermented drink] you might not manage [with charcoal]. I'm better off just buying firewood…because Thobwa requires a lot of fire to cook well" (69-year-old female [charcoal]).*	*"I light the jiko so that I can cook chapati" (34-year-old female [LPG]).*
Availability	*"I just use whatever is available on that certain day to cook with, if the other is not there whatever is there will be used" (58-year-old female [charcoal])*	*"It is not easy to find Koko [brand of ethanol] this side" (17-year-old male [ethanol]).*
	"There was this piece of wood laying around which I just decided to turn into firewood" (20-year-old female [firewood]).	
Weather	*"There is another complaint against firewood and charcoal, when you cook using them during the hot season the heat is unbearable that you might have to take off some clothes to withstand it" (66-year-old male [firewood])*	*"When it comes to charcoal when it rains, it lights up very bad" (19-year-old female [charcoal]).*
	"During the rainy season, wood is very hard to catch fire" 20-year-old female [firewood]).	
Other people's perceptions		*"If someone…sees you cooking with charcoal…they see you as foolish" (20-year-old male [kerosene]).*
Maintaining traditions	*"Before charcoal, people used to use firewood. I use both so that we should not forget our old ways of life" (66-year-old male [firewood]).*	

Kenya people described cooking 'ugali' (a thick dense porridge made out of maize) and chapatis, fish and eggs as well as a variety of vegetables or pulses (green beans, cabbage, beans and other greens). Often people bought pre-cooked foods and snacks from vendors (who are numerous in Mukuru) and re-heated those at home. In Ndirande, the staple food cooked was 'nsima' (also a dense maize porridge), as well as fish and chicken when available, and a variety of vegetables (potatoes, sweet potatoes, cassava, beans) and relish (a sauce to accompany other foods, made of tomatoes, onions and greens sometimes).

Most people in Mukuru cooked indoors, while in Ndirande it was much more mixed. Housing and the built environment are different in Mukuru and Ndirande, with outside space in Mukuru between housing being very limited, often consisting of narrow alleyways. In contrast, in Ndirande it is common to have a veranda on the front of houses and there is more space between houses. In Mukuru, people outlined a range of factors that either prevented them from cooking outside, such as the weather or their neighbors, while others had simply not considered it. In Ndirande participants often mentioned moving the place that they cooked. For example, one participant outlined how they cooked outdoors during the day, then indoors at night:

> "We fear we can get stoned…or maybe thieves, that's why we cook inside the house [at night]"
>
> (20-year-old female resident of Ndirande [briquettes])

Others moved their location for cooking due to changes of season or weather (e.g., needing to cook indoors in the rainy season) or because their place for cooking was being used for other things (e.g., hanging out washing). One participant outlined how where they cooked depended on the type of fuel they were using:

> "To avoid darkening the wall [with firewood smoke] we cook outside as the landlord wouldn't be happy… the landlord is open to cooking with charcoal indoors since it doesn't produce smoke"
>
> (66-year-old male resident of Ndirande [firewood])

Participants that used solid fuels for cooking often used other materials for ignition, including other solid fuel types, as well as items considered to be waste, including plastic (Fig. 3), paper, non-woven carrier bags and hand sanitizer:

> "When the paper catches fire that's what lights the jiko fast
>
> (48-year-old female resident of Mukuru [charcoal])

> "For a nice burn the fire needs plastic. If I don't add it, the fire does not burn"
>
> (16-year-old male resident of Ndirande [firewood])

These waste items originated from the household or were found around the community:

> "They were on the roof when it used to leak and now they replaced the iron sheets… so I thought we could use them for the fire… [adds a plastic plate to the fire during interview] I just found the plate like that, it should just go into the fire"
>
> (35-year-old female resident of Ndirande [firewood])

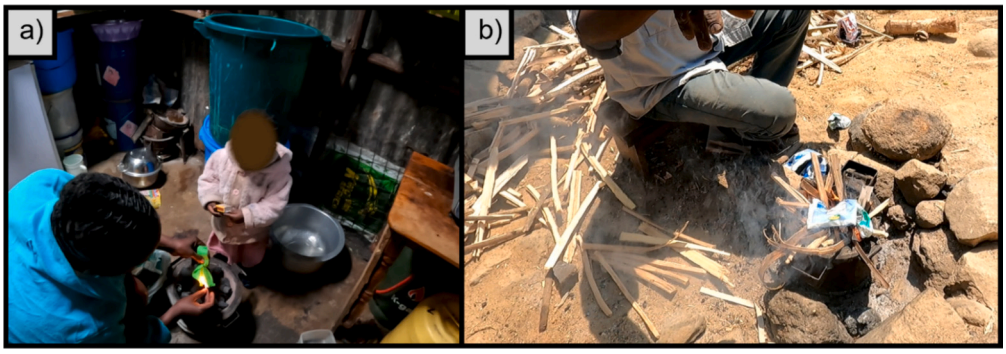

Fig. 3. Using waste plastics to help ignite the cooking fire: a) A mother in Mukuru uses plastics to light her charcoal burner with her daughter and (unused) LPG canister close by, and b) A man in Ndirande uses waste plastics to help light his fuelwood.

"Maybe sacks, yes even bottles, sometimes the crocs [a type of shoe] that people throw into this river. I go around collecting them"
(39-year-old female resident of Ndirande [firewood])

For some, the process of cooking was enjoyable (whichever type of fuel they used), while for others it was a necessary chore that took time away from other activities. Whether someone enjoyed cooking or not did not appear to be linked to location or fuel type. Particularly in Ndirande, participants outlined how cooking was intertwined with gender and family roles and responsibilities. However, there were suggestions from a few participants that times were changing, and gender roles were shifting.

"I cook because I am a mother"
(58-year-old female resident of Ndirande [charcoal])

"As a man I shouldn't really be cooking…It just happened that one day when my mother was away and I was hungry, I just decided to give it a try and was able to cook."
(19-year-old male resident of Ndirande [charcoal])

"Today's jobs [i.e. household chores] don't look at gender…They are all the same, because what if you only have boys?"
(35-year-old female resident of Ndirande [firewood])

Various health impacts were outlined by participants in Ndirande and Mukuru relating to breathing in smoke while cooking, including sneezing, coughing, dizziness, itching, teary and red eyes, headaches, catching flu, breathlessness, chest tightness, warmed up blood, blood clots and TB.

"The food will cook as tears run"
(66-year-old male resident of Ndirande [firewood])

"It goes into my chest, sometimes you start coughing. Your chest sometimes becomes blocked"
(48-year-old female resident of Mukuru [charcoal])

"Sometimes when you're blowing into the fire it's like you drink the smoke and you cough up a storm because of the smoke"
(35-year-old female resident of Ndirande [firewood])

In both informal settlements, the smoke-related health impacts were highlighted not only for the person cooking, but others in the household, especially children. It was very common in both communities for children to be involved in the cooking process or to play close by during cooking (see, for example, Figs. 1 and 3a). The health impacts of cooking with some fuels went beyond inhalation of the smoke and included burns:

"Sometimes the nsima you are cooking can land on you, or the oil can spill"
(16-year-old male resident of Ndirande [firewood])

Discussion

This study used the concept of the cooking journey - from 'fuel to pot' - to more holistically understand how household decisions are made about which fuels to use, the risks and challenges people are exposed to while obtaining fuel (in addition to risks and challenges experienced during the cooking process alone) and how people cook, in two African informal settlements (Ndirande in Malawi and Mukuru in Kenya). In comparison to previous work, this broad approach enabled us to address key recommendations for research in this space, namely to broadly consider the food-energy nexus (rather than focusing on one of these areas in isolation) (Shupler et al., 2021) and placing people's experiences at the heart of the research on fuel use (McCarron et al., 2020; Phillip et al., 2023). A better understanding of these factors in specific contexts may support the design of more effective and sustainable interventions. To center people's experiences of the cooking journey we used videoed 'go-along' interviews, which enabled us to experience the process of obtaining fuel and cooking whilst discussing what we observed and experienced with participants. In doing so, we found: 1) that decision-making regarding fuel use was complex, dynamic and context-specific (Section "Before the cooking journey begins"), 2) while focus is often placed on HAP exposure, risks and challenges are experienced by people across the cooking journey (Section "Obtaining fuel"), 3) whilst the debate of cooking on solid fuels is often focused on the main fuel sources (e.g. charcoal, wood), we found that waste (especially plastic) is commonly used when cooking with solid fuels (Section "Cooking at home"). Below we discuss each key finding, and their importance with regards to the wider literature.

Fuel-based decision-making is complex, context-specific and dynamic

In both communities, people often obtained small amounts of fuel daily or multiple times per day, in line with previous studies in Kenya and Malawi (Okore, Koske, & Letema, 2022; Osano et al., 2020; Phillip et al., 2025; Shupler et al., 2021). A range of factors fed into decision-making about which fuel to purchase or collect. These included, in order of mentions across both communities, time, cost, ease of use, health impacts, the type of food being cooked, availability, weather, other people's perceptions and maintaining tradition. The identified factors are similar to those highlighted in previous work (McCarron et al., 2020).

Given the well-established health impacts of cooking using solid (and other) fuels (e.g., Bennitt et al., 2021; Fisher et al., 2021; Zhou et al., 2024), the health impacts of using particular fuels factored into decision-making less frequently than might be expected, particularly in

Ndirande where a high proportion of participants used solid fuels. However, cooking decisions (e.g., whether to transition to clean cookstoves) are rarely driven by health concerns, but rather decision-making generally focuses on more immediate concerns such as cost (Jewitt et al., 2020; Saleh et al., 2021). It may also be related to the fact that cooking (and its health impacts) is so embedded in daily living that it is not taken into consideration (Muindi, Egondi, Kimani-Murage, Rocklov, & Ng, 2014). When people were pressed on the health impacts of cooking, most of them outlined potential smoke-related impacts, e.g., coughing, breathlessness, teary and red eyes, as has been reported in other literature (Parvizi et al., 2024; Saleh et al., 2021; Uny et al., 2024). The most common health impacts identified were immediate ones and it was much rarer for participants to highlight HAP-related diseases that were temporally distant, i.e., have a lag time like chronic obstructive pulmonary disease (Jewitt et al., 2020; Saligari et al., 2025). Some participants also highlighted a lack of understanding of the types of health impacts caused by cooking (e.g., warmed up blood). This highlights the need for health improvement campaigns (e.g., media-based) and education, something which Ndirande and Mukuru residents have highlighted that they would like more of in their community previously (Uny et al., 2024). The observed variations in the decision-making factors that were highlighted between the two settlements emphasizes the importance of understanding context, which is vital for designing suitable interventions to reduce reliance on solid fuels (McCarron et al., 2020; Saleh et al., 2021).

This research has shown that decision-making around cooking in both informal settlements (e.g., which fuel to use, where to cook) varies over short (e.g., meal-to-meal, daily) to long (e.g., over several years) timescales. Short-term decision-making depends on factors such as what is being cooked, which seller is available and whether it is raining. Longer-term decision-making considers factors like change in availability over time (e.g., availability of a new fuel type), change in season and change in family size. This complexity of decision-making has also been identified in relation to obtaining other household necessities such as drinking water in similar contexts (Adams et al., 2022). This change over time has important implications for the design of interventions to reduce HAP exposure in informal settlement communities. For example, interventions need to consider whether/how the season will change how and where people will cook and the fuel they use. While the emphasis here is on household decision-making, it's important to recognize that the decisions that people have the agency to make are not theirs alone. Rather, decision-making also depends on a range of (in)actions by various stakeholders at scales from the community-level to government- and international-level which makes fuels available or not (Uny et al., 2024).

Risks and challenges are faced across the cooking journey

Whilst the wider literature acknowledges the heavy physical and mental health burden placed upon people (particularly women and children) cooking with solid fuels (Lim et al., 2022; Milanzi & Namacha, 2017; Okello, Devereux, & Semple, 2018; Saleh et al., 2021; Woolley et al., 2022), there is little in-depth research around the risks and challenges that people may be exposed to across the whole cooking journey: before cooking begins, whilst fetching or purchasing solid fuels (Kyayesimira & Muheirwe, 2021; Sani & Scholz, 2022), particularly in informal settlements where the risks and vulnerabilities are already heightened (Amegah, 2021; Satterthwaite, Sverdlik, & Brown, 2019; Ssemugabo, Nalinya, Lubega, Ndejjo, & Musoke, 2020; Weaver et al., 2023). Our study contributes to filling this gap, particularly in informal settlement contexts, where over half of the African urban population lives (UN-Habitat, 2025). Participants outlined a range of risks and challenges that they experienced during the cooking journey, with exposure to gender-based violence on the journey being a common theme. In addition to any acts of violence themselves, the threat of violence can cause additional stress and anxiety for those collecting or purchasing fuels (Ho et al., 2021), and can lead to significant impacts on mental health (Shupler et al., 2022). Violence, particularly gender-based violence, has also been described in relation to journeys to fetch water (Adams et al., 2022) and journeys to sanitation facilities (Winter, Johnson, & Dzombo, 2023).

Some of the challenges observed through the videos (i.e., related to terrain and the built environment; Figs. 1 and 2) were not commonly raised by participants themselves. As in previous research on water fetching in Malawi (Adams et al., 2022), the use of videos in this study enabled the detection of a wider range of risks and challenges than identified by participants alone. Participants appeared to 'foreground' some risks and challenges (e.g., violence), while other risks and challenges (e.g., terrain, built environment) remained in the background. The pushing into the background of some risks and challenges might reflect how embedded aspects like terrain and built environment are in the informal settlements that people are living in, similar to the case of the invisibility of air pollution in informal settlements (Muindi et al., 2014; West et al., 2020).

If it burns it is burnt – the use of waste in cooking

Participants frequently told us how waste was used in the cooking process, often for ignition when cooking using solid fuels, as in previous work (Fedak et al., 2019; Muindi et al., 2014; Uny et al., 2024). For participants, this had the dual purpose of starting the fire and disposing of unwanted household items. Waste management is often non-existent in informal settlements, and so burning, whether that be in the household or open burning, is a way to get rid of waste (Pathak et al., 2023). In some cases, participants also picked up waste beyond the household to add to their fires. Much of the burnt waste was plastics (Fig. 3), adding to the currently limited evidence of the use of plastics as part of the fuel mix (Bharadwaj et al., 2025). The burning of plastic waste generates harmful emissions including particulate matter, bisphenol A, and polycyclic aromatic hydrocarbons (Velis & Cook, 2021), which are associated with a range of adverse health impacts (Pathak, Nichter, Hardon, & Moyer, 2024). Given the practice of burning plastics was commonplace among those using solid fuels in our study, further work is needed on a larger scale to quantify the amount of plastic being burnt and the health impacts of burning this plastic waste (Bharadwaj et al., 2025; Velis & Cook, 2021).

Similarities and differences within and across the settlements

Throughout the results and discussion sections we have outlined where we have identified similarities and differences within and between the two informal settlements, which we have drawn together here.

Key differences between participants' experiences of the food-energy nexus in Mukuru and Ndirande were the fuels used, where cooking was undertaken and the type of food being cooked. A key example of this was the common consumption of beans in both communities, but in Ndirande beans being cooked from scratch, while in Mukuru they were bought pre-cooked for re-heating, with implications for the quantities of fuel needed for their preparation in the household.

Despite these differences, there were many similarities from participants across the two communities, including the regular collection of small quantities of fuel, the dynamic decision-making regarding fuel use over multiple timescales, and the key factors feeding into fuel-based decision-making of time, cost and ease of use (more than the perceived health impacts of different fuels). Further shared themes included the many (often unrecognized) terrain and built environment related challenges experienced when obtaining fuel, the involvement of children throughout the cooking journey, the common use of waste (often plastic) to ignite the fire for solid fuel users, and that participants in both communities commonly highlighted the short-term health impacts of using particular fuels (e.g., coughing), rather than long-term

health impacts. Participants in both communities made clear that they perceived there to be a hierarchy of fuels, ranging from more to less desirable. That there are so many similarities between the settlements, despite the different energy system contexts, suggests that people's cooking journeys in informal settlements are underpinned by similar factors. This could be tested further by applying the same approach in other contexts, but could ultimately inform the design of fuel-based interventions in African informal settlements.

Similarities and differences between participants within each community were harder to identify due to the sample sizes, but people's enjoyment of cooking did not appear to be linked to gender or fuel type. In Ndirande in particular, females were more likely to raise concerns around personal safety during obtaining fuel than males. In Mukuru, cooking was undertaken indoors, while there was more variation in Ndirande, depending upon factors including whether the house was owned or rented and the fuel type.

Methodological reflections and limitations

Beyond questionnaires and static interviews, this study has shown how valuable it is to observe everyday practices by 'going along' to better understand how decisions at the food-energy nexus are made. 'Go-along' interviews enabled a dynamic conversation between the interviewer and participant, reacting to what was happening around them (e.g., during fuel purchase) and what the participant was doing (e.g., how they were lighting the fire). The addition of the video recording enabled the identification of some of the more 'hidden' risks and challenges that residents face, that they might not see as being risks and challenges themselves, for example because they are so ingrained in everyday life. However, 'go along' or walking interviews add an extra layer of challenge for the interviewer (in comparison to static interviews), and the researcher needs to be fully trained and confident in the method before undertaking the interviews. Undertaking these sorts of community-based interviews creates interaction 'moments' with other members of the community, and careful consideration needs to be given to ensure such interactions are handled appropriately and safely. In particular, safety needs to be fully embedded in the plans, with specific requirements varying by context.

Our findings have emphasized that cooking journeys are temporally dynamic, yet our 'go-along' interviews are snapshots of people's everyday realities. Future work could undertake multiple interviews, for example in different seasons, to better understand how the cooking journeys explored here are experienced by people over time. This could also help address the fact that, despite our participants practicing fuel 'stacking' and using multiple fuels in their households, we only joined them to fetch whichever fuel they were collecting at that time.

Conclusions and recommendations

This study, in two African informal settlements, has highlighted the complexity in decision-making across the food-energy nexus, from deciding what to cook, to which fuel is needed, to where to cook and how. Notably, decision-making is dynamic over various timescales and varies by context, as exemplified using our two case studies; Ndirande in Malawi and Mukuru in Kenya. Interventions designed to improve people's health in relation to cooking (for example in relation to reducing exposure to HAP), must factor in this temporal dynamism, context specificity and complexity. Co-design of interventions with those they are for should ensure that these factors are embedded in the design, and support more successful interventions. Ultimately the decisions that people can make, for example in terms of fuel choice, are limited by the context they are living in. It is therefore important that people are provided with more options to choose from and are supported to make choices that are better for their health and wellbeing. This will require action from key stakeholders including governments, non-governmental organizations, researchers and other stakeholders. While participants had some understanding of the links between using solid fuels for cooking and health, there were some misconceptions. This, together with the common use of plastics and other waste in cooking, reinforces the need for health education and community campaigns in informal settlements to increase awareness of the health risks. In our study we used a food-energy nexus lens to explore people's experiences of the cooking journey in African informal settlements. Our broad approach enabled us to identify the challenges people face not only during cooking (e.g., HAP-related), but across the entire cooking journey, including those faced during the process of obtaining fuel, e.g., gender-based violence. Such a framing is needed to inform the design of interventions aiming to support the move to cleaner fuels, reduce exposure to HAP, and improve people's cooking-related health, thereby contributing to the achievement of multiple SDGs, i.e., SDG 3 (good health and wellbeing), SDG 7 (affordable and clean energy), SDG 10 (reduced inequalities) and SDG 11 (sustainable cities and communities).

CRediT authorship contribution statement

Heather Price: Methodology, Funding acquisition, Formal analysis, Conceptualization, Writing – review & editing, Writing – original draft. **Fred Orina:** Supervision, Project administration, Methodology, Funding acquisition, Formal analysis, Conceptualization, Writing – review & editing, Writing – original draft. **Moses Chamba:** Methodology, Funding acquisition, Formal analysis, Conceptualization, Writing – review & editing. **Tracy Chasima:** Project administration, Methodology, Investigation, Formal analysis, Data curation, Writing – review & editing. **Line Caes:** Methodology, Funding acquisition, Formal analysis, Conceptualization, Writing – review & editing. **Limbani Kalumbi:** Supervision, Project administration, Methodology, Funding acquisition, Formal analysis, Conceptualization, Writing – review & editing, Writing – original draft. **Lusizi Kambalame:** Methodology, Funding acquisition, Formal analysis, Conceptualization, Writing – review & editing. **Siân E. Lucas:** Methodology, Funding acquisition, Formal analysis, Conceptualization, Writing – review & editing. **Hellen Meme:** Supervision, Project administration, Methodology, Funding acquisition, Formal analysis, Conceptualization, Writing – review & editing. **Mary Nyikuri:** Project administration, Methodology, Investigation, Formal analysis, Data curation, Writing – review & editing. **Sean Semple:** Methodology, Funding acquisition, Formal analysis, Conceptualization, Writing – review & editing. **Isabelle Uny:** Validation, Supervision, Project administration, Methodology, Funding acquisition, Formal analysis, Conceptualization, Writing – review & editing, Writing – original draft.

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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.

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