

## Article

# Women's Perceptions and Attitudes to Household Air Pollution Exposure and Capability to Change Cooking Behaviours in Urban Rwanda

Katherine E. Woolley <sup>1</sup>, Suzanne E. Bartington <sup>1</sup>, G. Neil Thomas <sup>1,\*</sup>, Francis D. Pope <sup>2</sup>, Aldo Muhizi <sup>3</sup>, Claude Mugabe <sup>3</sup>, Omar Ahishakiye <sup>3</sup>, Telesphore Kabera <sup>3,\*</sup> and Sheila M. Greenfield <sup>1</sup>

- <sup>1</sup> Institute of Applied Health Research, University of Birmingham, Edgbaston, Birmingham B15 2TT, UK; kew863@student.bham.ac.uk (K.E.W.); s.bartington@bham.ac.uk (S.E.B.); s.m.greenfield@bham.ac.uk (S.M.G.)  
<sup>2</sup> School of Geography, Earth and Environmental Sciences, University of Birmingham, Edgbaston, Birmingham B15 2TT, UK; f.pope@bham.ac.uk  
<sup>3</sup> College of Science and Technology, University of Rwanda, Kigali, Rwanda; aldomuhizi@gmail.com (A.M.); claude8m@gmail.com (C.M.); omarahisha@gmail.com (O.A.)  
\* Correspondence: g.n.thomas@bham.ac.uk or gneilthomas@gmail.com (G.N.T.); kaberaacris@yahoo.fr (T.K.)



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**Abstract:** Household air pollution (HAP) from cooking on biomass fuel presents significant health, environmental and socioeconomic consequences worldwide. However, there is a lack of understanding of the factors influencing cooking behaviours that affect HAP exposure in Rwanda (e.g., cooking location, removing children from the cooking area). Sixteen qualitative in-depth interviews were undertaken with women living in an underprivileged neighbourhood in Kigali, Rwanda. Deductive thematic analysis was carried out using the Behaviour Change Wheel (*Capability*—ability to engage with chosen activity, *Opportunity*—factors which are beyond the individual's control and *Motivation*—brain processes which direct behaviour: COM-B) to determine the thoughts and perceptions around cooking location and removing children from the cooking area. Facilitators and barriers were subsequently identified within the COM-B framework for the following HAP mitigation interventions: outdoor cooking, removing children from the cooking area and Liquid Petroleum Gas (LPG) use. Of the 16 interviewed, 12 cooked outdoors (75%), two (12.5%) cooked indoors (in the main home) and two (12.5%) in a separate kitchen. Despite the majority cooking outdoors, this was reported not to be a favourable cooking location. Levels of awareness of HAP sources and knowledge of the health effects of air pollution were observed to be limited, reducing women's capability to change, along with stated barriers of cost, housing constraints and safety. Factors out of the individuals' control (opportunities) included weather, socio-economic and educational factors. Preconceived beliefs, experiencing smoke reduction and the briefly described short-term health effects, directed motivation. Furthermore, participants identified a need for community-based education as a facilitator to changing their behaviour. Despite a high level of observed motivation towards reducing HAP exposure, many women lacked the capability and opportunity to change their behaviour. There are research and policy implications concerning development of community-based interventions which involved end-users and relevant stakeholders in the development process.

**Keywords:** household air pollution; behaviour change wheel; biomass cooking; LPG; Rwanda

## 1. Introduction

Over half of the global population cook using solid biomass fuels (wood, dung, charcoal, crop residue) in the indoor environment, causing harmful levels of household air pollution (HAP) responsible for approximately 4 million premature deaths each year [1], with women being the primary cooks. Biomass fuel cooking has major health implications throughout life course (e.g., low-birthweight, respiratory infections, chronic obstructive pulmonary disease (COPD)), cognitive impairment, etc.) [2–5] and also exerts adverse

environmental (e.g., deforestation, erosion, greenhouse gas emissions etc.) [6,7] and socio-economic impacts (e.g., gender inequalities, healthcare costs, opportunity costs etc.) [8,9]. There is a pressing need to develop and implement HAP interventions, with the ultimate long-term goal of cleaner fuel transition (e.g., Liquid Petroleum Gas (LPG), electricity, solar) in low-and middle-income contexts. However, cleaner fuel transition is often not complete or follows the “energy ladder” model with transient fuel switching and stove or fuel stacking [10] due to multiple barriers to clean fuel provision including access, financial costs and traditional cooking behaviours and cultural considerations [11–14]. During the transition period, structural or behavioural interventions which reduce HAP exposure may be introduced, such as improved cookstoves (ICS), outdoor cooking, removing children from the cooking area and improved ventilation; although it is recognised, changes in pollutant concentrations will not meet World Health Organisation indoor air quality guidelines (WHO-IAQ) [15].

Qualitative research provides a valuable tool in HAP intervention research, to understand awareness, attitudes and perceptions around biomass cooking and potential interventions, as well as enablers and barriers to change. Both traditional [16–19] and participatory [20,21] qualitative research methods have previously been used in HAP intervention research, highlighting facilitators of growing awareness of LPG [20], but barriers of cost [19–21], safety concerns with LPG [22], and possibly surprisingly a lack of knowledge regarding the long-term reductions in health risks associated with the cleaner fuel interventions [17,20]. A midwife-led behaviour change intervention introduced in health centres in rural Kenya indicated the important role of education in motivating women to change their cooking behaviour and share information within the community [18]. By identifying barriers at an early stage of intervention development, effective policies can be formulated to improve sustained adoption and change [16,19].

Rwanda is a small landlocked densely populated country in East Africa, with a population in 2020 of ~13 million [23]. Although classified as a low-income country, with a current GDP per capita of US\$ 797.9 [24], the Rwandan Government is economically ambitious, aiming to achieve upper-middle-income status by 2035 [25]. This rapid phase of economic development and population growth in recent decades has led to mass urbanisation and the rise of unregulated settlements, especially within Kigali, the capital. In urban areas in 2019, biomass was used for cooking by 80.3% of households, with a prominence of charcoal [26]. In May 2021 the Government of Rwanda announced proposals to phase out the sale of charcoal in Kigali due to its adverse health and environmental impacts [27]. The COVID-19 pandemic presented periods of economic uncertainty which led to cooking fuel switching in East Africa due to a change in market availability and household income [28]. Previous research undertaken in Kigali, Rwanda suggested that women are keen to adopt HAP mitigation interventions, especially ones that can suite a range of cooking patterns, and had positive attitudes towards educational initiatives [29]. In addition, the role of positive peer attitudes upon the uptake of biomass pellets [30] and the use of dynamic HAP concentration feedback with air quality sensors has proven an effective push tactic towards HAP lowering behaviours [31]. However, there is a research gap for the in-depth understanding of women’s perceptions of behaviour changes during the development of such interventions; addressing this research need has the potential for an increased intervention acceptability and uptake.

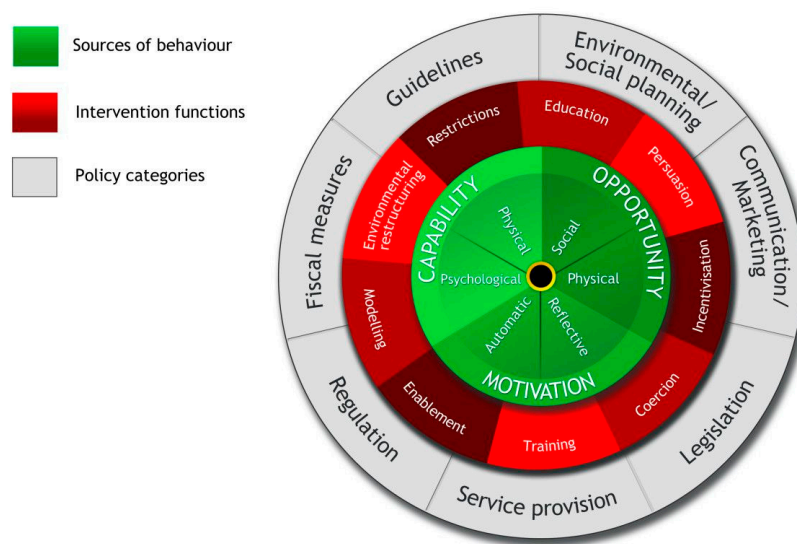
Therefore, to understand the role of behaviour change to inform potential cleaner cooking interventions in Rwanda, this study aims to explore (i) awareness of HAP exposure and associated health harms, (ii) awareness of HAP interventions and (iii) the facilitators and barriers to (a) outdoor cooking and (b) removing children from the cooking area.

## 2. Materials and Methods

### 2.1. Theoretical Grounding

The Capability, Opportunity, Motivation, Behaviour (COM-B) and Behaviour Change Wheel (BCW) framework were originally created to help inform the design of behaviour

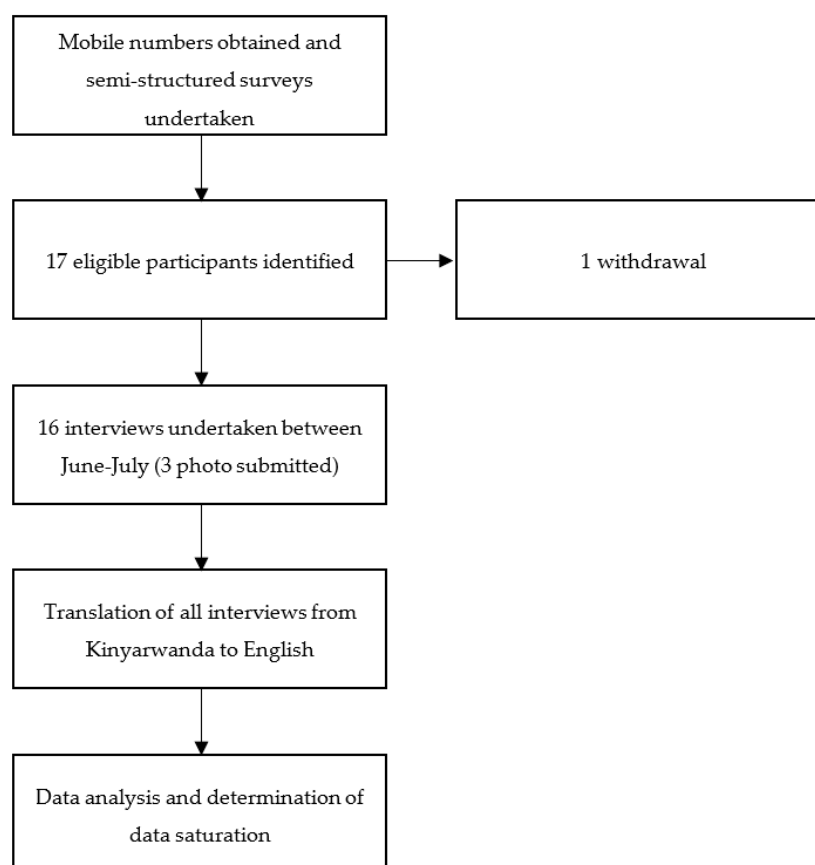
change interventions [32] and in this study was used to understand the theoretically derived determinants of behaviour change in cooking practices. The three components, ‘capability’ (ability to engage with chosen activity), ‘opportunity’ (factors which are beyond the individual’s control), ‘motivation’ (brain processes which direct behaviour), determine the ability for behaviour change [32]. Each of the sources of behaviour can then be divided into nine categories to further understand how the intervention may function (Figure 1), allowing the identification of areas to target [32,33]. Within this study, all three sources of behaviour are used to inform contextually specific behavioural strategies for HAP reduction.



**Figure 1.** The Behaviour change wheel [32].

## 2.2. Study Setting

The study was set in the Kabeza cell, which is a group of villages situated in the Nyarugenge district of Kigali city; an informal settlement comprising ~950 households in 7 villages (Hirwa, Ikaze, Ituze, Imanzi, Ingenzi, Sangwa and Umwezi), with a predominance of charcoal cooking on mobile single-pot stoves (Figure 3) [29,34]. Residents were eligible for participation if they (i) were the main female household cook aged 18–55 years (reproductive age), (ii) had a resident child under the age of 5 years and (iii) cooked mainly on charcoal and/or wood fuel(s). Eligible women were identified from a wider study on fuel switching which included a convenience sample [35] of mobile numbers provided by the cell and village leaders, who hold a list of mobile numbers of each household (Figure 2). Of 17 eligible women identified by the survey responses, all agreed to participate in the present study. There was one subsequent withdrawal, resulting in a total of 16 completed interviews. Participants were asked at the end of the semi-structured survey to submit a photographic depiction of air pollution prior to the interview which was used as descriptive context to support the analysis. All 16 interviews were undertaken between April–July 2021. Data saturation, where no new information is obtained within the analysis [36], could not be determined at the time of undertaking the interviews due to the time required for transcription and translation, compounded by delays caused by COVID-19 and expiry of ethical approval. Despite this, data saturation was achieved, and was determined during the data analysis of all collected interviews.



**Figure 2.** Flow diagram of the research process.

### 2.3. In-Depth Interviews

Participants were contacted to organise a convenient day and time for the interview, which all took place between 9 a.m.–5 p.m. on a weekday (June–July 2021), via mobile telephone. The interviews were undertaken by trained field workers (A.M., C.M. and O.A.; trained by K.E.W.) in Kinyarwanda, who were undergraduate students studying water and environmental engineering in the University of Rwanda College of Science and Technology and who also undertook the previous semi-structured surveys. Interviews were based on a topic guide (Table S1), which first asked participant to describe and explain the photo they had taken, to stimulate discussion. If the participant had not taken a photo, they were asked to describe what they thought air pollution was and why. The questions which followed covered the awareness of the health effect of household air pollution, views on behaviours to reduce exposure (e.g., moving cooking location and removing the child from the cooking area), what would enable them to make these changes and how they would like to learn more. Verbal informed consent was recorded prior to the interview. All interviews were recorded and professionally translated and transcribed by PageSix Transcription Services Ltd. (Isle of Wight, UK).

### 2.4. Data Analysis

Deductive analysis [37] was undertaken using the COM-B behaviour change wheel, with coding being undertaken while reading through the interventions, with allocation into the COM-B themes being undertaken using NVivo [38] to manage the data by K.E.W. Data on cooking location and health events were quantified from the interviews. A random sample of 10% of the responses were analysed by S.E.B, G.N.T., F.D.P. and S.M.G. for validation [39] and to check for discrepancies in the coding.

### 2.5. Ethical Approval

Ethical approval for data collection was obtained from the University of Rwanda College of Medicine and Health Science Institutional Review Board (CMHS IRB) (No. 235/CMHS IRB/2020) and the University of Birmingham (ERN\_19-0252). Participants were free to withdraw at any point and fully informed verbal consent was obtained.

## 3. Results

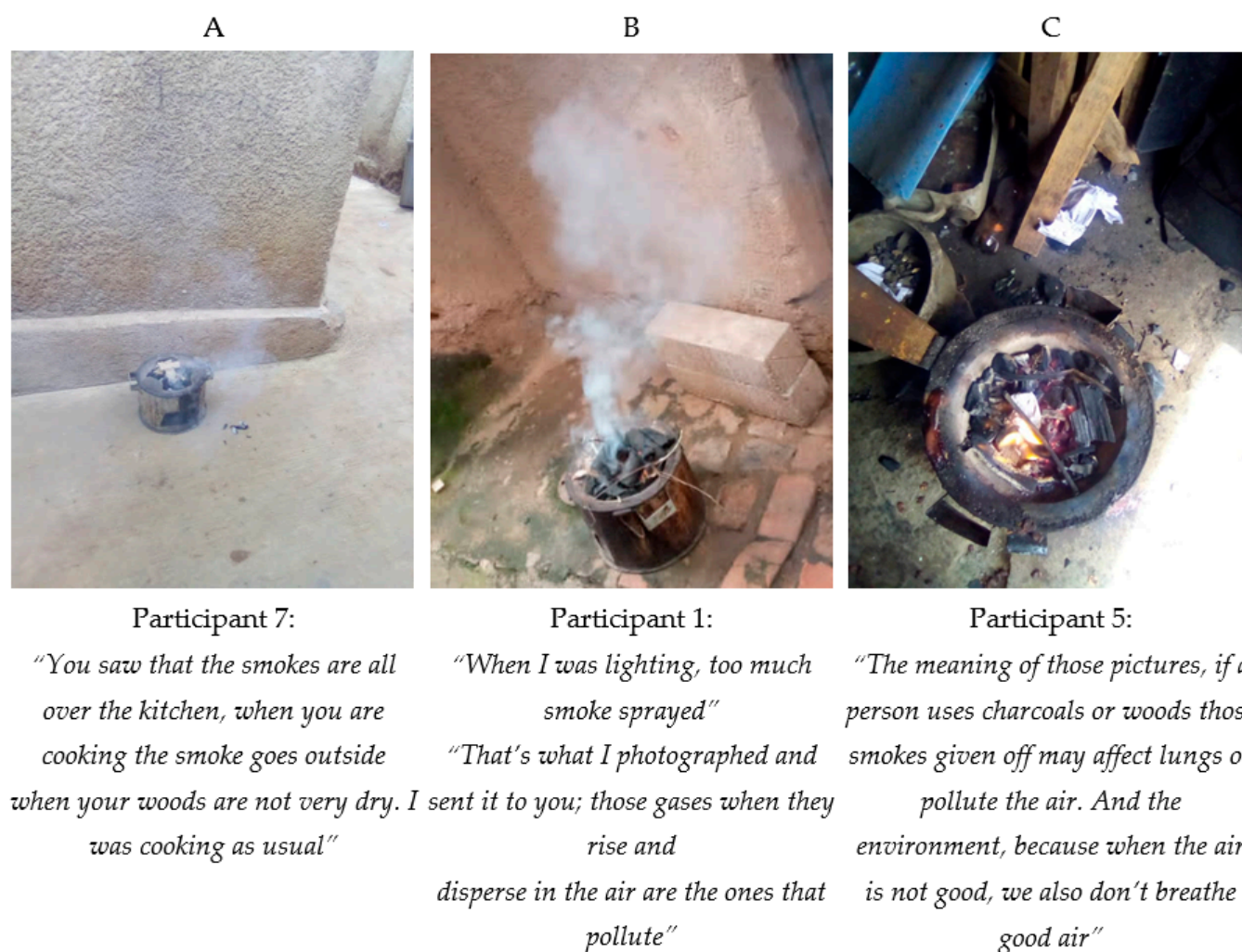
### 3.1. Participant Characteristics

Demographic information on the participants was obtained from the prior semi-structured survey (Table 1). The 16 participants were aged 25–55 years and had a median household income of 60,000 RWF (IQR: 37,500–112,500). The majority were employed in elementary occupations (e.g., cleaner, waiter, housekeeper) ( $n = 11$ ; 68.8%) and other occupations included service and sales workers ( $n = 3$ ; 18.8%), technician and professional ( $n = 2$ ; 12.4%). Charcoal was used by most participants (75%,  $n = 12$ ) with firewood used by four (25%). The majority of participants cooked outdoors (75%) with two (12.5%) cooking indoors and two (12.5%) in a separate kitchen. All three photo submissions were of cookstoves in outdoor ( $n = 2$ ) and indoor ( $n = 1$ ) cooking locations, describing the smoke produced from cooking (Figure 3).

Data from the interviews are presented in this section in the three major themes, ‘capability’, ‘opportunity’ and ‘motivation’ followed by a final section which presents the facilitators and barriers to behaviour change interventions. Out of each of the three themes, capability dominated the data, followed closely by motivation; however, little data in comparison was coded to the opportunity theme. Participant quotes are used to support the view presented by participants. Participants can be linked back to Table 1 which illustrated the individual characteristics of each participant.

**Table 1.** Basic participant characteristics for each interviewed woman.

Participant	Age (Years)	Occupation	Income (RWF)	Cooking Fuel	Cooking Location
Participant 1	35–44	Teacher	180,000	Wood	Outdoors
Participant 2	35–44	Housewife	60,000	Charcoal	Outdoors
Participant 3	35–44	Security worker	100,000	Charcoal	Outdoors
Participant 4	25–34	Casual worker	300,000	Charcoal	Separate kitchen
Participant 5	25–34	Housewife	60,000	Charcoal	Separate kitchen
Participant 6	35–44	Casual worker	20,000	Wood	Indoors
Participant 7	55–64	House cleaner	50,000	Charcoal	Outdoors
Participant 8	35–44	Casual worker	30,000	Charcoal	Outdoors
Participant 9	45–54	Housewife	100,000	Charcoal	Outdoors
Participant 10	35–44	Hair dresser	250,000	Charcoal	Indoors
Participant 11	25–34	Casual worker	40,000	Wood	Outdoors
Participant 12	35–44	Casual worker	30,000	Charcoal	Outdoors
Participant 13	35–44	Mobile seller of vegetables	60,000	Wood	Outdoors
Participant 14	35–44	Casual worker	20,000	Charcoal	Outdoors
Participant 15	25–34	Casual worker	50,000	Charcoal	Outdoors
Participant 16	25–34	Business woman	150,000	Charcoal	Outdoors



**Figure 3.** Pictures and associated captions provided by participants documenting the traditional charcoal stoves in an outdoor setting (A,B) and indoor setting (C).

### 3.2. Capability

The capability theme covered the ability to engage with behaviours that can reduce HAP exposure, which includes psychological (e.g., awareness of the problem) and physical (e.g., housing and financial constraints). Women reported a lack of clear awareness of the source of air pollution, with nine identifying briefly that cooking fuels cause air pollution, describing it as smoke from cooking. Two participants identified two alternative sources of smoke exposure including plastic bags used as firelighters, lighting and grass burning. One participant claimed that charcoal production generated air pollution rather than the burning of fuel for cooking.

*Participant 9: "Smoke from cooking wood pollutes the air"*

*Participant 11: "The first thing is the smoke from the grass they burn. The second thing is the charcoal we burn and what we use to start the fire, like the plastic bags. The third thing is the cars that use petrol, I don't know, they emit gases that pollute the air we breathe"*

Identification of other sources was lacking and could only be gained with further prompting. The health effects of HAP exposure were also vaguely described by providing few substantive or known health events, reporting events including headaches, dizziness, eye irritation and respiratory issues among the women.

*Participant 13: “Sometimes I bend down to fetch food from the pot or turn the food, and then the smoke rises in my face causing dizziness, tears, and mucus to run from the nose, and it becomes clear that the smoke is causing issues”*

However, there was a lower level of knowledge of the health harms affecting children observed, with one woman reported that her child did suffer from respiratory issues but did not think this was attributable to cooking smoke.

*Participant 11: “I have a child among mine who suffers sinusitis, but that [smoke] wasn’t the cause”*

Respiratory complaints ( $n = 4$ ), burns ( $n = 3$ ), headache ( $n = 2$ ) and heat ( $n = 1$ ) were the commonly reported health events due to HAP exposure in children, otherwise no events were reported. One woman did identify the difference in the vulnerability between herself and the children stating

*Participant 3: “For me it takes time to be contaminated but the child not”*

This lack of knowledge of both the sources and health effects of air pollution indicated that women have a lack of capacity to make informed decision about their cooking fuel use.

*Participant 15: “What I can tell you now is that I now have a sick child at the hospital with breathing difficulties. I don’t know if it is because of the smokes”*

Women also reported a general lack of ability to change their cooking practices. The ability to cook outdoors was affected by: safety issues, housing constraints, belief that cooking location should be determined by stove type and belief that outdoor cooking was a last resort. The safety of outdoor cooking was mainly a concern to women in regards to children, typically the risk of burns from playing near the stove, or being by the door; but one woman cited security and potential risk of sabotage with outdoor cooking.

*Participant 6: “The reason is that if I cook from outside the children, who are playing, can be burnt. That’s why I don’t cook from outside”*

*Participant 13: “The method that could help me would be to find something that doesn’t emit smoke or excessive heat, so that I can start cooking inside the house. Because cooking outside the house isn’t a good practice. Sometimes dirt does fall into the pot, and it’s also possible that bad people might come and add dangerous stuff to the food and endanger the whole family. Cooking outside is good in terms of preventing smoke but it’s not generally a great thing”*

*Participant 5: “It is the security of the house, because you have a place to cook from and prepare things”*

The lack of space and housing constraints are reported reasons why women cook outside; they would prefer cooking areas within a kitchen in a separate building, which they currently do not have. However, there was a lack of identification of solutions to enable them to cook outdoors, as women saw it as the last resort, and saw LPG as the solution; but they lacked the capacity to change to LPG.

*Participant 3: “No, where I cook is not where I want to cook, this is because of the lack of capacity. Because if I had the means, or if I was the owner of the house because I am the tenant, I should build for the gas in the right place and to cook there. This kitchen also, I will move it away from the door. In short, it’s the lack of means that forces me to cook where I cook today”*

Barriers to LPG cooking were strongly portrayed by the women. These included a lack of equipment, the fact that gas comes in large volumes, that gas cannot be used outside and the cost of gas.

*Participant 10: “The first thing is that I can’t carry gas and place it outside”*

*Participant 1: “It is the problem of high price. Gas is expensive and to find it is also expensive because they sell a big gas bottle, there is no small bottle with fewer kilograms”*

One participant noted that they had security issues with gas, recounting her previous experience of her equipment being stolen. However, financial constraints ( $n = 11$ ) mainly in regards to LPG, was highly cited as a barrier to cooking fuel access: one woman reported that charcoal was expensive; two women reported that they would like to purchase gas in the same way they buy charcoal, in small amounts. In addition, the women stated that they require more information about the cost and equipment for gas. Financial restrictions limit women's capability of switching to cleaner fuels.

*Participant 1: "The suggestion is that the government would help us and reduce these gas prices and set up a way for one to go and put in a little gas he can afford, as we do when we buy a bucket of charcoal"*

The ability to keep children away from the cooking area elicited mixed responses, indicating various capacities to reduce their child's exposure to air pollution. Seven women stated that they were able to keep children away from the cooking area, with one woman stating that it is the parents' responsibility to keep children occupied so that they stay away from the cooking area. However, the woman did state that they were only able to keep children away most of the time. Only one woman clearly said that she was unable to keep children out of the cooking area.

*Participant 13: "There haven't been any consequences except that when I am going to cook, I keep them at a distance and I tell their older sibling to keep them away so they don't risk getting burned or spill something hot on themselves. So, there have been no consequences, because they don't come near the fire"*

*Participant 12: "You can't be able to keep children away when you are cooking"*

### 3.3. Opportunity

Environmental factors, socioeconomic factors and lack of education reduce the opportunities for women to take up behaviour change interventions, on top of the necessity to cook. The ability to cook outdoors was reported to be limited by wind and rain; however, when asked what could facilitate them to be able to cook outdoors, no suggestions were given, only that cooking with gas was a better solution.

*Participant 8: "So, when it rains, in the case of us who are renting houses without a kitchen, we who are poor, you just move the cooking stoves into the house when it rains"*

*Participant 15: "Cooking from outside, some time there is wind or charcoal are burnt quickly, but I do it to protect myself from the smokes of the stove. Because I had problems when I placed it, I cannot do it again"*

Housing constraints also reduced women's opportunity to cook outdoors due to a lack of space, with women suggesting that building open spaces and better housing would facilitate outdoor cooking.

*Participant 7: "But if you have the ability you can build the one with an open space, to reduce the disease you can cook from outside. It is good"*

Women have little control over their housing due to a reported low socio-economic standing. One participant noted that sickness prevents the ability to work and this subjects them to a healthcare cost, therefore, they do not have any spare money to go towards paying for more expensive fuel. Support from the government was also cited to help with access to LPG and develop intervention support.

*Participant 3: "So when a person is sick, or physically damaged in that way, that person cannot work for development, because he is always sick and always at the doctor. And the money he had, it will be used to treat his illness"*

*Participant 16: "It can be better while government help its citizens to have access to Liquid Petroleum Gas"*

Women stated that they required more knowledge of HAP exposure and consequences, forthcoming fuel restrictions and alternative options that are available to them. Community meetings, newspapers, radio, television, leaflets, phone messages, linking producers and consumers together and face-to-face training were all suggested by the women as formats in which they were willing to learn more about reducing HAP exposure. However, some women noted that not all households have access to a television and radio and it is therefore not always convenient.

*Participant 13: "Yes, I feel like I want to know more about this issue, the danger of it, and how one can protect oneself from it, and the ultimate consequences that it leads to"*

*Participant 7: "Talks on the radio, some may not have TV but many listens to the radio"*

*Participant 16: "I also like to use telephone too, because it can be on radio while I am not around, so that can be lost"*

### 3.4. Motivation

The motivation theme covers the automatic and reflective brain process that influence the behaviours that can reduce exposure to HAP (e.g., previous experience and beliefs). Women were generally motivated towards reducing pollution, though limited education, as described above, mean polluting fuels can still be chosen, with one woman citing that she has switched to charcoal from wood to reduce pollution.

*Participant 7: "Yes, we switched to charcoals, now I won't try any other thing"*

In addition, there were mixed beliefs as to where cooking should take place, with four reporting that cooking should be done in the house as this was the seen as the social norm, six reported outdoors or in a ventilated space and five reported in a kitchen, indicating underlying assumptions in the motivation behind cooking location. Women demonstrated a motivation to cook outdoors due to the negative aspects of cooking within the house, which included making the house hot, dirty and bad smelling. Conversely, there was some awareness of the benefits associated with cooking outdoors, including reducing pollution, being away from children and protecting children.

*Participant 12: "Cooking outside shouldn't be happening, people should be cooking in kitchens"*

*Participant 11: "Because it allows the smokes to get away and avoid polluting the house and disturb children"*

Women expressed negative opinions concerning outdoor cooking including impact upon neighbours.

*Participant 7: "When you start a fire the smoke spread all over and reach the neighbour"*

*Participant 12: "Cooking outside is difficult, it's not easy. And it spreads smokes that pollute the atmosphere"*

This concern was also reflected in one of the submitted photographs, when one woman said she identified the closest form of air pollution to her, which was a burning charcoal stove situated outdoors. In addition, outdoor cooking was cited as not being easy, nor was it good practice, which indicated a reduced motivation to cooking outdoors. Despite this, the benefits which motivated women to cook outdoor were more widely reported among participants than the negatives.

*Participant 13: "Because cooking outside the house isn't a good practice. Sometimes dirt does fall into the pot, and it's also possible that bad people might come and add dangerous stuff to the food and endanger the whole family. Cooking outside is good in terms of preventing smoke but it's not generally a great thing"*

LPG was considered the ultimate option for reducing smoke exposure, and although the negatives of LPG featured more heavily than the positives, it was recognised that LPG reduced the child's exposure to HAP. However, women were concerned about the risk of

explosions, the safety of the gasses produced from LPG and their lack of experience using it. Encouragingly, they were motivated to change due to previous or neighbour experience.

*Participant 14: “Cooking on gas generates bad smoke in the house”*

*Participant 16: “lack of experience of using Liquid Petroleum Gas for cooking”*

*Participant 13: “The reason why I cook outside is that when you place the cooking stove on the house’s cemented floor, the fire burns quickly. And it could be possible that smoke can cloud the entire house and prevent you from breathing, causing you to cry and to drip mucus and sneeze a lot. It might also cause death to people, depending on who has a low tolerance to smoke, and that person might suffer consequences. That’s why I stopped cooking in the house and decided to cook outside. However, after realising that lesson, I started taking care of the situation, so it doesn’t lead to problems anymore”*

### 3.5. Summary of Barriers and Facilitators

Each behaviour change type was dominated by barriers (Table 2), with a few facilitators ( $n = 5$ ). Of the five facilitators three were motivators and two came under the ‘capability’ theme. However, all opportunity themes were barriers, indicating the current limiting factors were around women not having the ‘opportunity’ or ‘capability’ to change their behaviour. The benefits of outdoor cooking and impacts of indoor cooking were seen as facilitators to cooking outdoors, but despite this motivator, there remained barriers around the belief of where cooking should take place and the negatives of outdoor cooking. Other barriers to outdoor cooking were presented as a lack of capability (e.g., housing constraints and safety) and opportunity (e.g., weather). Conversely, capability was both a facilitator and a barrier to keeping children out of the cooking area in terms of outdoor cooking enabling children to be out of the cooking area and keeping children occupied. In addition, education was both a barrier and facilitator in providing capability for women to change their behaviours. The only facilitator observed with LPG was the motivation towards health improvements; however, barriers remained within women’s capability (e.g., financial and equipment availability) and opportunity (e.g., poverty cycle and governmental help) to take up the use of LPG.

**Table 2.** Barriers and facilitators identified from in-depth interviews, categorised by theme, cooking behaviour and fuel type.

Cooking Behaviour	Code	Theme	Barrier	Facilitator
Outdoor cooking	Weather	Opportunity	X	
	Housing constraints	Capability	X	
	Benefits of outdoor cooking	Motivation		X
	Negatives of outdoor cooking	Motivation	X	
	Safety	Capability	X	
	Belief about where cooking should take place	Motivation	X	
	Impact of indoor cooking	Motivation		X
Keeping children out of the cooking area	Outdoor cooking	Capability		X
	Keeping children occupied	Capability	X	
LPG	Ability to use LPG –equipment, security, safety	Capability	X	
	Financial constraints	Capability	X	
	Health improvements	Motivation		X
	Governmental help	Opportunity	X	
	Poverty cycle	Opportunity	X	
Education	Awareness of sources, consequences and options	Capability	X	X
Previous experience and neighbours’ experience		Motivation		X

#### 4. Discussion

This novel in-depth interview study, using mobile phone technology in an informal settlement in Kigali, investigated women's perception of HAP and their views on cooking behaviours, identifying factors which influence the capability, opportunity and motivation on cooking behaviour (e.g., outdoor cooking) that reduces HAP exposure. To the best of our knowledge there have been no other qualitative studies investigating behavioural change HAP interventions in Rwanda. Barriers to reducing exposure to HAP were seen within factors associated with capability (e.g., housing and financial constraints and safety concerns) and opportunity (e.g., weather and lack of governmental support), compared to motivation which included the largest number of enabling factors (e.g., health improvements associated with outdoor cooking, previous personal experience and neighbours' experiences). Encouraging behaviour which reduced HAP exposure could have potential health benefits for women and children, with supportive education informing women of the options to switch to cleaner cooking.

Descriptions of sources of air pollution and associated health effects were vaguely described within this study, with very few reported health effects among children. Of those health effects identified, they were either short-term (e.g., eye irritation, dizziness or headaches) or respiratory, which corresponds with previously published literature [17,21]. Conversely, positive perceptions towards activities that reduce pollution exposure identified within the interviews included cleanliness and lower smoke production, which have previously been reported within the literature as motivators towards intervention adoptions [30]. Health benefits have not always been seen as the driving force behind behaviours to reduce exposure [17,40] and maybe this is due to a lack of clear awareness in both individual and child health benefits, as demonstrated by this study.

Women wanted to cook with LPG indoors; however, due to being unable to do this, they chose to cook outdoors to reduce their exposure due to their awareness of the consequences of HAP, suggesting a level of agency within their decision making. Direct benefits of lower pollution, less dirt and location away from the children were identified as motivators for outdoor cooking; however, no health benefits were mentioned by the participants. This observation of less focus on health effects and more towards immediate impacts such as cleanliness and short-term symptoms has also been documented in previous studies from Latin America [17,41]. External factors (e.g., weather, security and housing constraints) limit women's capability to engage with outdoor cooking; however, women were unable to identify solutions to enable them to cook outdoors when raining such as a covered area. Being unable to identify solutions may be due to women rationalising and accepting their current situation resulting in a lack of agency to change their current conditions [42]. An alternative behaviour change is to remove children from the cooking area, and the women in this study reported that they were capable of removing children from the cooking area, which was also aided by cooking outdoors. However, previous research showed that women often struggled to keep children out of the cooking area [29], suggesting that there may be situational factors, such as time of year, cooking location and data collection methodology, along with a potential response bias which may explain the difference in these results.

Even though the focus of this study was on cooking location and removing children from the cooking area, women highlighted the use of LPG, which could be a reflection that women have a desire to move towards LPG, rather than change their current cooking behaviour with charcoal. Although women do want to transition to LPG, which is also documented within the literature [43], there remain barriers in women's opportunity and capacity to use LPG, despite being motivated by the benefits of LPG. Previous studies have shown that an awareness of the benefits of LPG is often not the limiting factor but instead financial capacity in being able to afford the equipment and gas cylinders. In this study women report wanting to pay for LPG in small amounts, which has also been documented with in a recent successful pay-as-you-go LPG pilot study in urban Rwanda [44]. Although barriers included financial capacity and safety concerns, which are previously documented

within the literature [16,22,29,43], it is likely that there are multiple interconnected barriers that need to be overcome to enable sustained adoption. In addition, female empowerment, also documented in the literature [45,46], and female cooks [47] are factors of a successful uptake of cleaner cooking, and, therefore, factors that address gender disparities and improve empowerment within the household environment should be considered in future studies [48]. Governmental policy to break down financial barriers to access to LPG should take into consideration energy supply disruptions and economic instability, as seen with the COVID-19 pandemic, to enable continued and sustained supply [13]. In addition, taking feedback in an iterative way to stakeholders should reduce some of the barriers, such as buying LPG in the same way as buying charcoal in small quantities.

However, financing, governmental support and situational factors are not enough on their own to ensure changes in cooking behaviours [16] and, therefore, should be supported by adequate education to improve individual empowerment and agency. Community perception of interventions is key [49] to enabling women to be capable, motivated and have the opportunity to change this behaviour. Women in this study were keen to learn about HAP, its consequences and options, via a variety of different information sources, which should be considered within the service provision. Therefore, explaining different methods and options to break down barriers, including the relative benefits of different fuels and differences in cost are required and have previously been shown to be effective [17,50]. In addition, the role of previous experience and neighbours' experience should not be underestimated, with the use of platforms to share previous knowledge facilitating this, which has been identified in earlier literature [51]. A previously suggested solution was to encourage community leaders to adopt cleaner fuel to convince community members to transition to cleaner fuels [17,52], which was shown to be effective in sanitation interventions [53]. Without further knowledge of HAP and alternative options, supplied in an accessible format, the women do not have the opportunity to make changes themselves. Therefore, our research indicates the need for local policies to improve community-based initiatives—such as education regarding the harms of poor air quality at Umuganda—that can empower behavioural changes to reduce HAP exposure.

### *Strengths and Limitations*

In depth-interviews via mobile telephone, undertaken by Rwandan nationals, gave rich information pertaining to cooking behaviours. Mobile telephones provided an important mechanism for remote research during COVID-19 restrictions, however, there were distraction and connection issues, which could have taken the participants' attention away from the interview. In addition, only three photovoice responses were gained, highlighting the issue of technology poverty within the study area, as some of the reasons provided for not taking a photo were that the participant did not have access to a phone camera; however, no obvious participant characteristic differences were noted. Those photos submitted could be affected by response bias as they were all of cookstoves and the fact that they had access to a phone with a camera could imply they had a relatively higher socio-economic standing. Despite the limitations of photovoice submission within this study, the detail provided within the pictures and description gave more detail and understanding than those participants who were asked to describe air pollution, illustrating the benefit of participatory research, if barriers to technology are accounted for in the study design. Some of the western researcher influence of the interviews, which ranged from 7–27 min, would have been reduced by being conducted by Rwandan nationals. However, the interviewers, though trained, were not qualitative experts, and some of the nuances in meaning may have been lost in translation though professional translators were used. Cooking location responses could have been influenced by the fact that interviews were undertaken at the end of the rainy season and beginning of the dry season, when outdoor cooking is more prevalent, although social acceptability bias may have led to the higher than expected levels of outdoor cooking participants. We did not collect information describing concurrent use of multiple fuel or stove types, however, there was no indication of fuel or stove stacking

behaviour in the survey or interviews. This aligns with our existing knowledge obtained by primary field observations that the mobile single-pot charcoal fuel stove is the dominant cooking practice in the Kabeza cell [29,34].

The COM-B wheel provided a useful tool in identifying which factors that influence behaviour need targeting in an intervention; however, there was some potential overlap between the themes. For example, the awareness of the sources of HAP and the consequences were coded as ‘capability’ due to women being unable to engage with an intervention, but it could have been an ‘opportunity’ as provision of education is out of the individual’s control. In addition, the data could not provide any information on the further layers (intervention function, policy categories) of the COM-B wheel; which would have provided more details on the design of an intervention.

Future research should consider rural and urban differences, views and perceptions of stove stacking and differences in perception between males and females, as male heads of household often make purchasing decisions [43].

## 5. Conclusions

Within this study, women were motivated (e.g., health improvements and previous personal and neighbours’ experiences) to reduce their exposure to HAP but felt they lacked the capability (e.g., housing, financial, safety and ability to use LPG) and opportunity (e.g., weather, governmental, health and poverty cycle) to change their cooking behaviours and therefore reduce HAP exposure. There was a willingness to learn and adopt new behaviours as a community in this context, which has implications for the implementation of community-based initiatives. Policies to address both sociocultural and structural barriers are required to support individuals to make behaviour changes to reduce HAP exposure.

**Supplementary Materials:** The following are available online at <https://www.mdpi.com/article/10.3390/su14031608/s1>, Table S1: Topic guide.

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