sustainability

MDPI

Case Report

Influencing Motivations Linked to the Adoption of Improved Flame-Based Cookstoves among Indigent South African Households: A Behaviour-Centred Design Approach

Marcel Maré [1,*], Mugendi K. M'Rithaa [2] and Alettia Chisin [1]

[1] Department of Applied Design, Faculty of Informatics and Design, Cape Peninsula University of Technology, Cape Town 7535, South Africa
[2] Department of Design, School of Humanities and Social Sciences, Machakos University, Machakos 90100, Kenya
* Correspondence: marem1969@gmail.com

Abstract: The adoption of energy-efficient, clean, and safe cookstoves can improve the health of poor sub-Saharan households and reduce mortality and poverty, as identified in the United Nations' Sustainable Development Goals (SDGs). Despite multiple interventions to increase the adoption of improved stoves and clean fuels, few interventions have borne fruit on a significant scale. The lack of adoption is shared in South Africa. (1) Background: The deleterious health hazards associated with flame-based cooking mainly affect women and children due to using portable and cheap paraffin (kerosene) cookstoves or self-constructed metal barrel wood stoves. A shift to improved cookstoves requires significant changes in users' behaviour. Understanding and addressing the motivations for cookstove adoption and long-term use is critical for successfully implementing behavioural change campaigns. (2) Methods: A case study methodology is employed to evaluate the effectiveness of a behaviour-centred design (BCD) approach aimed at influencing cookstove-related motivations among low-income households in Dunoon, South Africa; the study gathers data via structured observations, co-creative workshops, and card-based choice questionnaires before and after a pilot intervention. (3) Results: The survey conducted before and after the abridged BCD intervention implementation in Dunoon indicates that the majority of touchpoints achieved significant success in influencing the selected cookstove-related motivations of the sampled households, further corroborated by an observed shift in household cookstove ownership patterns targeted by the intervention. (4) Conclusions: A BCD approach suggests possible methods for understanding and influencing the complex motivations determining cookstove use in a context similar to South Africa. The results suggest that linking pertinent motivations to a selected set of touchpoints as part of a cookstove-related campaign can influence cookstove-related motivations linked to the adoption of improved flame-based cookstoves in a localised South African low-income context.

Keywords: behavioural design; behaviour centred design; improved cookstoves; UN sustainable development goals

Citation: Maré, M.; M'Rithaa, M.K.; Chisin, A. Influencing Motivations Linked to the Adoption of Improved Flame-Based Cookstoves among Indigent South African Households: A Behaviour-Centred Design Approach. *Sustainability* **2023**, *15*, 5328. https://doi.org/10.3390/su15065328

Academic Editors: Tang Tang and Jun Zhang

Received: 14 January 2023
Revised: 8 March 2023
Accepted: 13 March 2023
Published: 17 March 2023

1. Introduction

As of 2021, 2.4 billion people lacked access to improved cooking technologies. This number has increased since 2019 in sub-Saharan Africa, with an estimated additional 200 million people without access to these technologies [1,2]. Despite broad support for finding solutions to inefficient and dangerous cookstove-related practices, only a limited number of interventions have succeeded at scale [3,4]. The lack of a transition to improved cooking alternatives in response to large-scale interventions in South Africa has followed a similar trajectory [5–7]. Using unimproved biomass, coal or paraffin-fuelled household stoves persists among energy-impoverished South African households [5]. Mortality linked to cookstove-related burn injuries is among the highest globally [8]. Despite many efforts to

alleviate the adverse effects of flame-based cookstoves among energy-poor South Africans, successful interventions are rare [9–11]. A few localised South African studies have included behavioural approaches to assess how households are affected by the harmful effects of flame-based cooking appliances [12–14]. Current government initiatives in South Africa propose displacing paraffin with Liquefied Petroleum Gas (LPG), accompanied by subsidies to increase affordability and educational awareness campaigns [15].

Several behavioural change approaches have been assessed when designing and evaluating improved cookstove (ICS) interventions [16,17]. Research has increasingly focused on understanding the motivations for the adoption and long-term use of improved cookstoves, which is crucial for realising the associated health and environmental benefits [17–19].

The design category of behavioural design has received increasing attention [16,20,21]. The category of behavioural design encompasses a wide array of approaches [22–24]. The BCD approach, in particular, offers a novel approach to designing interventions, incorporating theoretical perspectives that span evolutionary, ecological and cognitive psychology, neuroscience, robotics, behavioural economics, social marketing, and human-centred design [23,25]. This attention is attributable to the approach's success in the related water and sanitation fields [16,26–29]. In South Africa, the kerosene distributed for domestic use is referred to as illuminating paraffin. Conforming to local usage, in the remainder of this article, we will simply refer to this fuel as paraffin.

1.1. Main Research Objectives

This paper assesses the effectiveness of a BCD approach to understand and influence the motivations linked to the adoption of improved flame-based cookstoves in a representative South African community. The main objectives are to

- Provide a brief overview of the South African cookstove-related behavioural context;
- Identify the target population for improved flame-based cooking stoves in South Africa;
- Conduct a case study-based assessment of selected aspects of a BCD approach seeking to influence cookstove-related motivations linked to the adoption of improved flame-based cookstoves in a representative South African community.

1.2. Limitations of Research

The study investigated a BCD intervention on a pilot scale in South Africa. Limitations such as time and budget limitations resulted in a narrow focus in the study, with some aspects not being fully addressed. The short timeframe for data collection required a primarily qualitative approach and may have affected the results. In mitigation, efforts were made to recruit participants from different socio-economic backgrounds. The pilot implementation was conducted in English and isiXhosa, which allowed for free expression but resulted in the need for later translation into English, leading to the potential loss or alteration of meanings. The detailed assessment of current stove designs found in the literature or the plethora of behavioural design research methods and techniques with the following aspects of the investigation were outside the scope.

2. Background

This section briefly reviews selected aspects of the BCD approach, followed by background to the challenges associated with using flame-based cookstoves in South Africa as proposed by Aunger and Curtis [23]. The contextualised description of the challenge is followed by a literature-based segmentation of the target population [23].

2.1. Selected Aspects of the BCD Approach

The BCD approach employs an iterative phase-based intervention design process incorporating human-centred design methods in designing, delivering and evaluating behavioural interventions [23]. The phase-based design process includes the following steps:

i. Setting a clear behavioural goal in meeting the behavioural challenge;

ii. Building an understanding of the behavioural determinants, specifically the underlying human motivations;
iii. Creating an intervention linking the goal-related motivations to touchpoints in a proposed campaign sequence;
iv. Implementing the proposed intervention in a real-world environment;
v. Evaluating the intervention process and outcome [23].

2.1.1. Setting a Behavioural Goal in Response to an Identified Challenge

Robert Aunger and Valerie Curtis [23] propose setting a clear behavioural goal targeting a clearly defined group of people to guide the design and delivery of an intervention. The material environment comprises the biological and physical objects and infrastructure present in the behavioural setting (i.e., kitchen, fireplace, cookstoves, chimneys, cooking ingredients and petroleum gas (LPG) cylinders) [23]. The socio-institutional factors include the multiplicity of social, economic, demographic, and political factors affecting the specific setting (i.e., affordability of goods and services, the availability of financial instruments, or the level of urbanisation) [23].

2.1.2. Understanding Human Motivations

Unique to the BCD approach is incorporating the complex motivations directing nearly all human behaviour [23]. The fifteen preeminent motivations are categorised according to biophysical, emotional, and learning motivations arising primarily from evolutionary adaptations [23]. The biophysical motivations shared with other vertebrates and invertebrates are satisfied by passing resources from the environment into the body (e.g., food for hunger and heat for comfort) or avoiding the loss of internal resources (e.g., disgust at rotting food or fear of fire) [23]. The emotional motivations are predominantly triggered by the environmental setting, with affiliation, nurturing, attraction, and love shared with other mammals; status shared with other primates; and justice being exclusively human [23].

2.1.3. Mapping of Touchpoints to Underlying Goal-Linked Motivations

The BCD approach accommodates the mapping of critical motivations to a series of touchpoints to achieve the overriding behavioural goal in an intervention [23,30]. Drawing on service design literature and practices similar to the case described by Jürisoo et al. [21], the BCD approach accommodates the mapping of touchpoints as the points of contact or interaction between people in an intervention [31]. The description focuses on non-physical interactions in a behavioural setting. Unique to a BCD approach is linking the distinct human motivations determining behaviour to points of interaction (i.e., touchpoints) in an intervention [23,30]. The mapping should proceed in partnership with a creative team or established change agency [23,30]. Each touchpoint in an intervention seeks to achieve a startling and memorable experience with each participant that stands out sufficiently to revaluate an underlying motivation leading to a change in the targeted behaviour [23,30].

2.1.4. Evaluation of the Design and Delivery of Interventions

The final key aspect of a BCD approach outlines the inclusion of appropriate research methods and instruments for a reliable assessment of the design and delivery of behavioural interventions [23,30]. The BCD literature provides a comprehensive set of analytical methodologies for increasing the validity and reproducibility of a BCD implementation [30,32,33]. The critical aspects of behaviour can be assessed by evaluating the role of selected aspects of the cascading cause–effect linkages in the performance of a behavioural intervention [23,30].

2.2. Cookstove-Related Context in South Africa

The challenge linked to flame-based cooking has deep cultural roots. The cultural use of flame-based cookstoves in South Africa has a rich and complex history [34–37]. The origins of these cooking traditions can be traced back to a mixture of African, European

and Asian influences [36–38]. Over time, these influences have blended to create unique regional variants that retain a shared African material and socio-institutional legacy [38,39]. The cooking routines of energy-poor black African households are characterised by a hybrid collection of these influences, with a clear shift away from traditional culinary practices [36,38,39]. Given the diversity of South African culinary culture, a locally focused approach that adapts to each community's specific needs is recommended [40,41]. The history of flame-based cooking in South Africa demonstrates the power of cultural assimilation and adaptation over time, resulting in a unique and diverse culinary landscape [37,42,43].

The South African challenge of deleterious health hazards associated with flame-based cooking is particularly amplified by overcrowded living arrangements, poorly designed and manufactured appliances and weakening social support structures, with the brunt of these effects falling on female cooks and their children. Female cooks prepare meals with portable and cheap paraffin cookstoves or self-constructed metal barrel wood stoves, leading to injury and disease due to hazardous emissions, burns and fires [5,44]. A recent increase in paraffin-based cooking is further attributed to the escalating cost and unreliability of electricity supplies [45,46], despite the recent introduction of improved methanol stove alternatives. Inefficient, self-constructed biomass stoves are linked to severe respiratory problems [10,47]. Many improved biomass stoves have been introduced over the years without success [48]. South Africa's use of LPG among low-income households remains conspicuously low globally compared with similar emerging countries [49,50]. Price controls and subsidies have been introduced in response [46]. Many LPG stoves are available in stores with a negligible localised focus on low-income households [51]. A summary of locally available flame-based cookstoves and their improved alternatives at the time of the study is depicted in Figure A1 (Appendix A).

2.2.1. Biomass Cookstoves

Biomass cookstoves are widely used in rural and urban areas of South Africa and play a central role in preparing meals for large social gatherings [11,47]. While the preference for wood-fired cooking is attributed to the taste that wood imparts on food, the continued use of fuelwood threatens household energy security. Despite a range of improved biomass stoves being available, they tend to be expensive relative to other technologies and are not widely known [52,53]. While biomass-based interventions have been proposed as an alternative, they have not been successful [52,53].

2.2.2. Paraffin Cookstoves

In South Africa, paraffin-based cooking stoves are predominantly used by low-income households due to their affordability, portability, convenience, and lack of competition [5,45]. While the total consumption of paraffin in South Africa has declined, its use among impoverished households has remained unchanged [5,45]. Non-pressurised paraffin wick stoves and heaters dominate the market [5,45]. Concerns have been raised about the poor quality and safety of these stoves. While improved alternatives are available, they are not yet commercially viable for low-income households [54]. The pervasive obnoxious odour of paraffin has led to a decline in paraffin stove use among younger generations.

2.2.3. LPG Cookstoves

The use of LPG among low-income households in South Africa is low due to various structural factors in distribution, sale, and regulation, resulting in high prices [9,50]. The availability of natural gas in neighbouring countries and offshore gas reserves in South Africa could lead to natural gas becoming a more important fuel. The LPG industry provides well-designed cylinders and stoves with effective regulation for gas refilling. The safety risks associated with a large-scale LPG strategy include inadequate regulation and institutional environments at local community levels. KayaGAS is an exception, distributing LPG in low-income settlements and providing a convenient, clean and relatively safe single-hob gas stove for cooking and heating water and homes [9,55]. Cast-iron gas stoves

are also available from various suppliers. Disadvantages include the safe management and distribution of LPG cylinders, the risk of cylinder explosions, and the limited availability of LPG cylinder refills in rural areas [9].

2.3. Segmentation of the South African Target Population

A literature-based segmentation was applied to determine the prospective South African population using inefficient cooking stoves facilitated by data sourced from the Socio-Economic Measure (SEM) Establishment Survey [56,57], supplemented by general household survey reports [58,59]. The lower SEM groups are still racially skewed in representation, with 98% of people in the SEM1 group being black Africans [56,58]. The use of inefficient flame-based cookstoves is prevalent among black South African households living in the bottom four SEM bands representative of South Africans living in poverty [56,58], as summarised in Table 1. The lack of durable appliances indicates that electric cooking only becomes affordable within the SEM3 and SEM4 groups [58]. The ownership of small electric devices grows from a low of 5% in SEM1 households to nearly 84% in SEM4 households [56]. SEM1 households predominantly depend on fuelwood as a fuel source, with paraffin as a fuel source being reported at 12%, implying a low level of paraffin stove ownership [58]. SEM2 households are predominantly headed by black African females, with negligible ownership of durable goods, but with radios and mobile phones being ubiquitous [56]. SEM3 households have some high school backgrounds, with minimal ownership of durable appliances [56].

Table 1. SEM group results summary (SEM1–SEM4) [56,58].

Household Criteria by SEM Group	SEM1–SEM2	SEM3–SEM4
Primary caregiver	>50% female	>50% female
Location	Rural, urban	Urban, rural
Income type	Social grant Irregular income	Social grant Irregular income Some wages
Monthly income, including social grants	R3 404–R4 275	R5 210–R6 434
Cooking energy source	Paraffin Electricity Biomass	Electricity Paraffin LPG

3. Methodology

A case study methodology is employed in this study to assess the success of a BCD approach in influencing motivations linked to the adoption of improved cooking technologies in a representative South African sample area [39,60]. The phase-based case study accommodates an adaptive methodology adjustable to various applications combining multiple research methods and instruments, as depicted in Figure 1.

Data collection during the case-based intervention design process took place from February to December 2017. The implementation was conducted by the behavioural change agency BREADrev from 12 August to 27 September 2017 in the representative sample area of Dunoon, Western Cape, South Africa. The data collection instruments comprised structured observations of cookstove ownership and card-based choice (CBC) questionnaires before and after the interventions.

3.1. Study Setting

The case study was conducted in the representative sample area of Dunoon in the Western Cape province of South Africa. The area exhibits rural and urban characteristics associated with South Africans being vulnerable to the hazards of flame-based cooking appliances, as indicated by their population distribution, economic and social development levels, and geographic location.

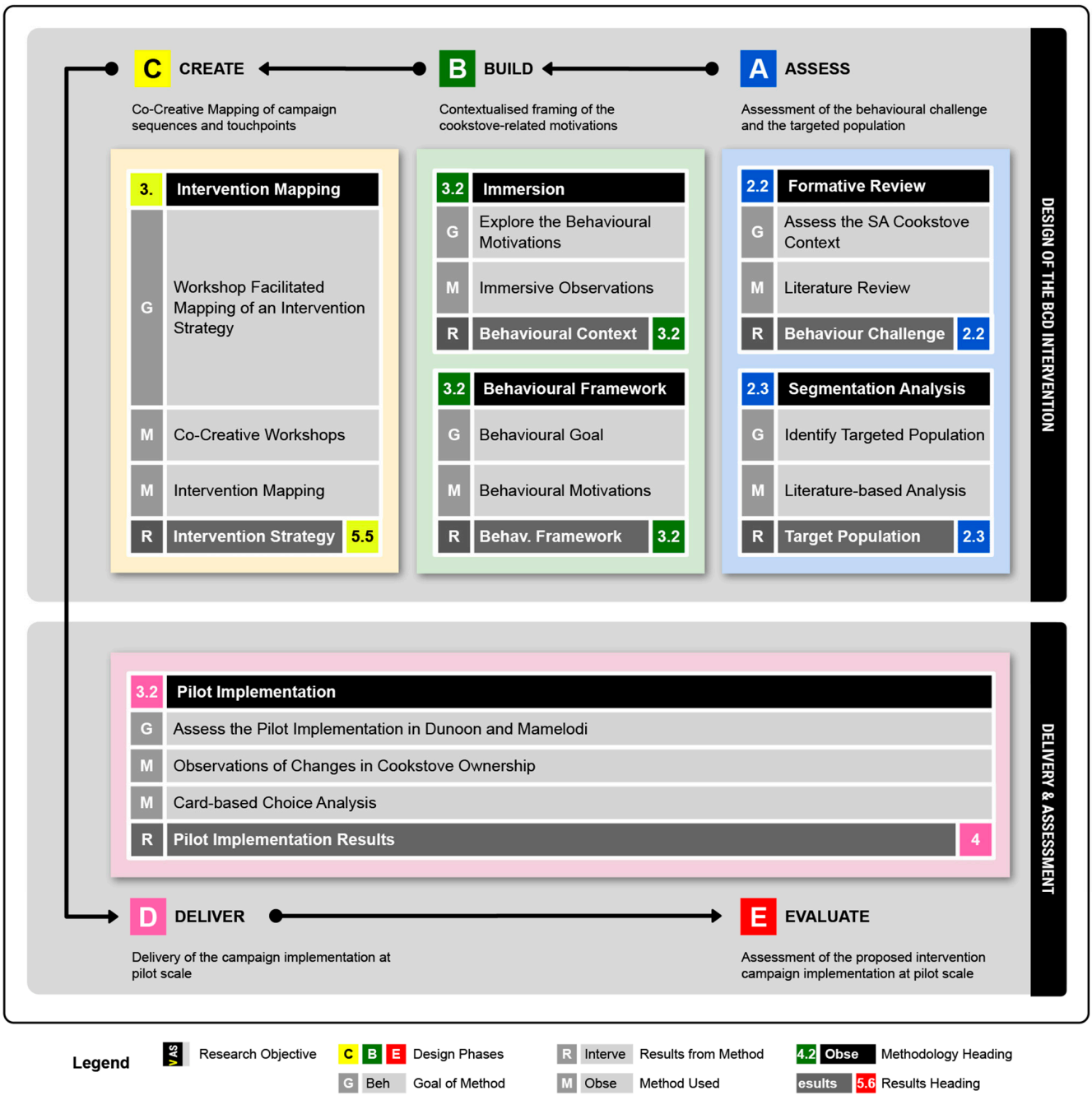

Figure 1. Phase-based case study framework.

3.1.1. Sample Selection

The community participants were selected and recruited through consultation with local community representatives and experts guided by the previously described segmentation. The study sample was selected to determine the motivations that could influence the adoption of flame-based cooking appliances rather than actual patterns of cookstove use in a specific geographic location. The representative sample of South African households was selected to reflect low-income families with limited access to credit living in dwellings constructed from a mix of corrugated iron sheets, mud, and brick. The intervention campaign aimed to primarily benefit female caregivers and children residing in these representative settings.

3.1.2. Ethical Considerations

Approval for the research was obtained from the Cape Peninsula University of Technology Ethics Committee (2 March 2017). The research's nature and purpose were explained to respondents orally and in writing before the survey began. The respondents were reminded of the ensured confidentiality and thanked for their participation.

3.2. Intervention Design and Delivery

The study designed and delivered a behaviour-focused intervention following the BCD approach. The insights gained from the researcher's immersion in Dunoon are distilled within an abridged framework articulating a behavioural goal and a summary of goal-linked motivations. Critical aspects of a testable intervention were created using a co-creative workshop method around a set of motivation-linked touchpoints. The case study then outlines the pilot implementation in the representative sample area. The case study culminates in evaluating the pilot implementation outcomes, specifically, the motivations targeted by the touchpoints linked to adopting improved cookstoves.

3.2.1. Behavioural Goal

A clear behavioural goal was set in response to the behavioural challenge faced by the South African target population. The goal is formulated as a synthesised response to the behavioural challenge affecting a targeted population segment set in a specific material and socio-institutional environment. The goal is to increase the adoption of improved biomass stoves, similar to the Stovetec EcoZoom or the single-hob LPG stove (similar to the KayaGAS Combo) depicted in Figure A1.

3.2.2. Explorative Framing of Cookstove-Related Motivations

Immersive nonparticipant observations by the researcher in the Dunoon study area were undertaken to develop a broad understanding of the motivations of under-resourced South African households using flame-based cooking appliances as depicted in Figure 2. A framing is employed to synthesise insights in a guiding framework for the design of an intervention comprising contextually related motivations drawing on primary and secondary data [30,61].

Figure 2. Porridge cooked over a self-constructed metal barrel stove observed during the immersion in Dunoon.

Guided by the categories suggested by Aunger and Curtis [23], the motivations associated with using flame-based cookstoves, summarised and tabulated in Table 2, include hoarding stoves and fuels as scarce resources and the motivations of social affiliation and status. The reasons for switching to a better cookstove are primarily unrelated to gains in long-term respiratory health. The motivations of hunger, comfort, fear, and disgust related to the daily grind of poverty are proposed for inclusion in a prospective intervention. The motivations categorised by hoarding, creativity, affiliation, and status are included. Motivations for learning linked to curiosity and play are included, which could act as possible touchpoints in an intervention. Motivations of lust, love, and attraction are excluded from the further investigation due to the complexity and rapidity of changes observed in gender roles at home and in the workplace in South Africa.

Table 2. Individual motivations linked to flame-based cookstoves.

Motivation	Description of Behavioural Motivations
Hunger	Food is primarily cooked to still hunger in impoverished settings [62]. Aroma exposure is frequently targeted in triggering hunger to sell food [63].
Comfort	Comfort is frequently targeted by tailored stove features (i.e., portability or stability when used on untiled and uneven surfaces) [64]. Comfort is furthermore derived from heating homes with flame-based stoves in the colder winter months [65].
Fear	Fear of injury from gas and paraffin stove explosions or fire is observed [66]. Fear is attributed to the inferior quality of stoves and a lack of knowledge on how to cook with novel cookstove alternatives [51].
Disgust	Disgust is frequently linked to flame-based cookstoves. Disgust motivations are linked to the taste of food cooked over paraffin stoves [44]. Disgust is attributed to the pungent smell of paraffin or smoke associated with dirty homes and clothes [44].
Nurture	Maternal nurture motivations are linked to the hazards of unimproved flame-based stoves [67]. Nurture motivations can be targeted as the women cook, nurture, and care for their children close to where the meals are prepared in cramped settings [68].
Hoard	Resource scarcity is strongly linked to hoarding motivations. The poverty level strengthens the motivation to hoard multiple cookstove types and fuels to meet the many competing household needs and hedge against unpredictable socio-economic circumstances [69].
Create	Creative motivations are observed in the culinary routines and recipes in preparing meals under severe constraints [70], as exemplified by the creative adaptations in preparing steamed bread [71].
Affiliation	Affiliation motivations to build trust and strengthen social cohesion are observed through sharing food or cooking together [72]. Cooking with family and friends maintains social relationships, forms alliances, and establishes norms [61]. Social pressure to adopt novel cooking appliances has found success [18].
Status	Status is frequently recommended in cookstove interventions [44,73]. An improved stove could be linked to the perception of a higher standard of living. Low status is associated with the odours emanating from poorly constructed wood and paraffin stoves [44].
Justice	Justice is frequently and ineffectively targeted by regulatory means in South Africa to trigger shame, followed by sanctions or fines associated with using unimproved cookstoves [74]. Illegal electric connections and unsafe paraffin stoves proliferate despite the regulations and standards [74].
Curiosity	Curiosity could be linked to cooking luxurious foods with a novel, improved stove [75]. In a Malawian case study, a novel stove piqued curiosity, leading to the transgression of social norms [76].
Play	Play motivations can be linked to learning how to use an improved stove in simulated activities, demonstrating the dangers without the risks of injury [77]. Improved cookstove interventions are frequently accompanied by the controlled demonstration of candidate cookstoves [64,78].
Love and Attraction	The ability to cook, linked to the collection of firewood and food preparation to attract a partner in a South African context, is still observed yet has diminished in importance [79]. The preparation of romantic meals is less common to all genders and orientations in low-income contexts [80].

3.2.3. Co-Creative Mapping of Campaign Touchpoints and Motivations for an Intervention

A series of collaborative workshop-based activities served to map out the relevant touchpoints and motivations for an intervention campaign guided by the framework [22,81,82]. BREADrev, a local change agency with experience designing and implementing local community interventions, facilitated the co-creative mapping of intervention sequences and touchpoints in partnership with participants drawn from Dunoon (Figure 3).

Figure 3. Facilitated baking sequence with improved biomass oven at a community bakery training school (July 2017).

The mapping of the workshop-based activities proposed a community bread-baking intervention adapted from similar BREADrev initiatives. Two sequences emerged following existing local recipes. The first sequence intends to increase the adoption of improved biomass stoves (similar to the Stovetec EcoZoom). It proposes an amended baking demonstration centred around an improved biomass oven performed by trained change agents drawn from the local community. The touchpoints for the first sequence of baking bread with an improved biomass oven and the second sequence of serving tea with an LPG stove comprise the following:

T01: Showing the lighting of the novel improved biomass oven to instil the motivation of curiosity;
T02: Exposing beneficiaries to the warmth of an improved biomass oven linked to the comfort usually provided by imbaula stoves;
T03: Spreading the appealing aroma of freshly baked scones emerging from the improved biomass oven to spark hunger;
T04: Baking local scone recipes together during the first biomass sequence triggers the motivation for playful learning;
T05: Showing the fuel savings associated with the improved biomass oven to revalue motivations related to hoarding household resources;
T06: Accentuating a clean cooking stage where clothes remain smoke- and odour-free during the biomass sequence, targeting status motivations;
T07: Sharing scones triggers motivations for affiliation associated with cooking together in shared settings.

The second sequence is intended to trigger the increased adoption of LPG double-hob stoves (similar to the KayaGAS offering) through the demonstration of serving snacks and tea prepared with an LPG stove by trained change agents. The intervention touchpoints included in the second sequence are

T08: Lighting an LPG stove repeatedly to reduce the fear associated with LPG appliances;
T09: Demonstrating an auto-ignition switch on a high-quality LPG stove during the LPG sequence to target status motivations;
T10: Releasing a briefly lit paraffin stove's pungent smell to spark disgust;
T11: Exhibiting the warmth emanating from an LPG heater linked to the comfort usually provided by paraffin heaters;
T12: Viewing an uncontrolled paraffin conflagration triggers the motivation of fear linked to paraffin appliances;
T13: Serving tea and scones with the participating beneficiaries and facilitating light-hearted banter while preparing the tea together during the LPG sequence ensures a safe and relaxed atmosphere to facilitate the affiliation motivation.

3.2.4. Delivery of the Intervention Campaign

The delivery of the intervention campaign proceeded in the representative sample area of Dunoon from 12 August to 27 September 2017. BREADrev facilitated the pilot implementation with three trained facilitators guided by the mapped campaign sequences and touchpoints, as depicted in Figures 4 and 5.

Figure 4. Baking of scones with the improved biomass oven by trained BREADrev facilitators in Dunoon.

Figure 5. Sharing of scones baked with the improved biomass targeting affiliation motivations.

3.2.5. Evaluation of the Case-Based Intervention Design and Delivery

The case study concluded with a survey of changes in cookstove-related motivations linked to the intervention touchpoints assisted by a CBC questionnaire in the sample area before and after the pilot implementation [60,83,84]. Structured observations of cookstove ownership complemented the questionnaire.

The CBC section of the questionnaire consisted of 36 cards to assess the touchpoints by targeted motivation (i.e., hunger, fear, disgust) linked to locally available and affordable improved flame-based appliances categorised by the three fuel types (i.e., biomass, LPG, and paraffin). The survey employed a visual CBC design with choice sets depicting photos of real stoves (Figure A1) linked to visualisations of each motivation reflecting the stove attributes under investigation (Figure 6).

Figure 6. Pre-coded list of illustrated cookstove-related motivations.

Each card-based question collected ordinal data assessing each motivation's perceived positive or negative connotation to the three stove types rated as binary choices of "agree" and "disagree" with the added option of "neutral/don't know". Each level was visually represented with a "thumbs up", "neutral", and "thumbs down" icon below each stove image on each card (Figure 7). A short pre-coded descriptive narrative of each depicted motivation was prepared. Similar to the assessment of motivations, the structured observations of stove ownership were characterised as nominal data (i.e., yes, no, and other/don't know) for each stove type categorised by fuel type. Statistical analyses of the collected survey data augment the assessment.

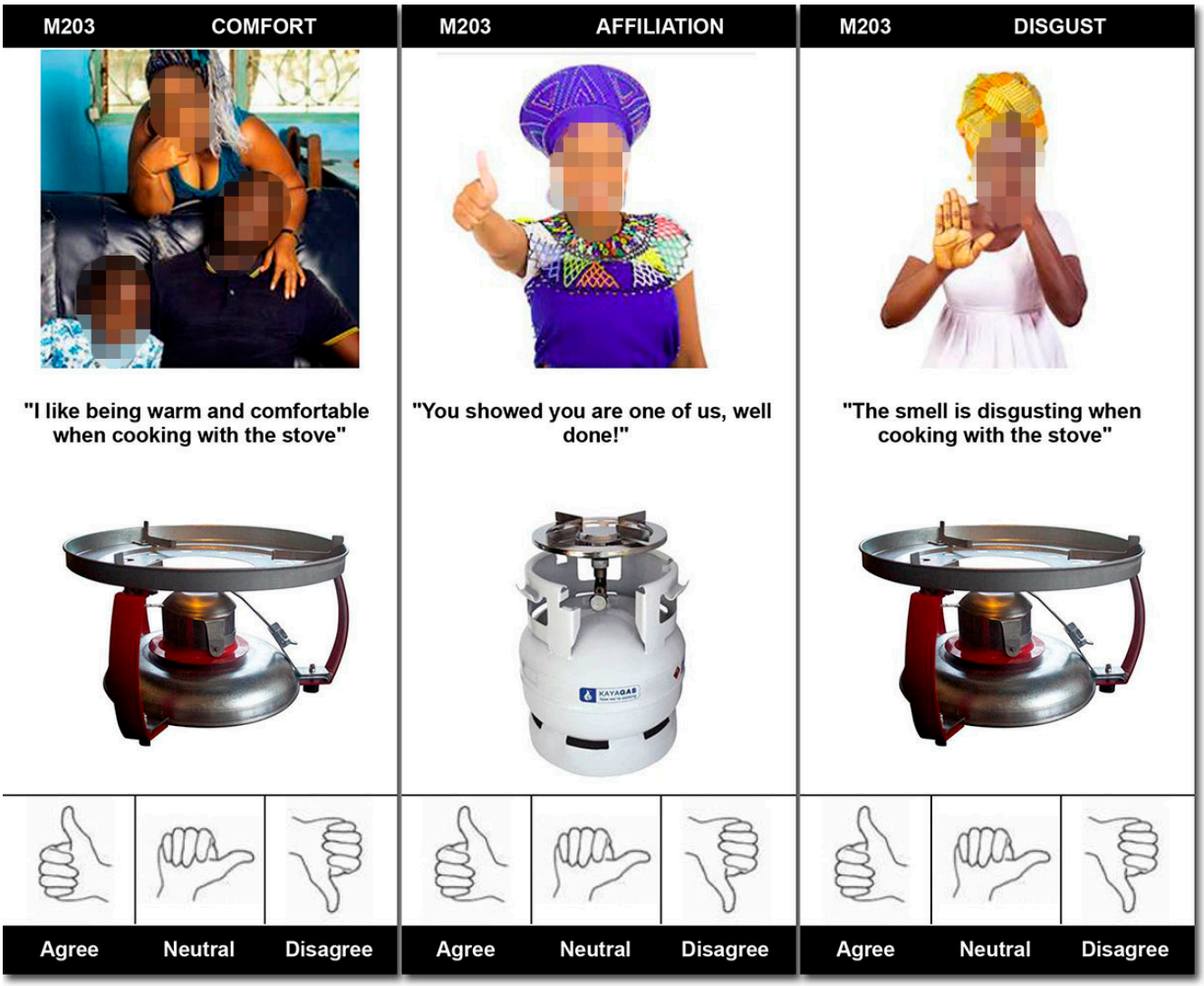

Figure 7. Sample cards depicting the pre-coded list of behavioural motivations targeted by the selected intervention touchpoints.

4. Results

The survey results conducted before and after the abridged BCD intervention implementation in Dunoon indicate that most touchpoints successfully influenced the selected cookstove-related motivations of the sampled households. The CBC results were further corroborated by an observed shift in household cookstove ownership patterns targeted by the intervention. The results record an increase in the adoption of LPG stoves and improved biomass stoves. Nevertheless, no significant reduction in paraffin stove ownership levels has been recorded.

4.1. Changes in Observed Stove Ownership Levels

The structured observations recorded during the household survey indicate a successful shift in the ownership patterns of flame-based cooking appliances after interventions, as depicted in Table 3. A key result was the significant increase in LPG stove ownership of 23.9% ($p = 0.044$). A significant increase of 18.0% in biomass stove ownership ($p = 0.049$) was observed. The differences in observed cookstove ownership patterns for paraffin stove types between the control and post-intervention populations were not large enough to be statistically significant.

Table 3. Change in flame-based stove ownership patterns for Dunoon (direct comparison of difference-in-differences adjusted for control).

Stove Ownership by Energy Carrier	Control			Post-Campaign Unexposed				Post-Campaign Exposed				Effect Size (Difference in Differences) *a*			
	n = 99	%	SD	n = 53	%	SD	*p*-Value	n = 44	%	SD	*p*-Value	% Exp.	% Unexp.	% DID	*p*-Value
Biomass stove	58	58.6	0.5	23	43.4	0.5	0.161	27	61.4	0.5	0.009	2.8	−15.2	18.0	0.049
Paraffin stove	37	37.4	0.5	12	22.6	0.5	0.235	13	29.5	0.5	0.360	−7.8	−14.7	6.9	0.538
LPG stove	16	16.2	0.4	3	5.7	0.2	0.009	13	29.5	0.3	0.243	13.4	−10.5	23.9	0.044

a Significant differences at $\alpha = 0.05$.

4.2. Changes in Touchpoint-Linked Motivations

The difference-in-differences (DID) statistical analysis (Table 4) indicates significant changes in touchpoint-linked motivations between households surveyed in the control and post-intervention sample at baseline (i.e., not exposed to the intervention) and endline (i.e., exposed to the intervention).

Table 4. Changes in cookstove-related motivations for Dunoon (direct comparison of difference-in-differences adjusted for control).

Touchpoint-Linked Stove Motivations	Control			Post-Campaign Unexposed				Post-Campaign Exposed				Effect Size (Difference-in-Differences) *a*			
	n = 99	%	SD	n = 53	%	SD	*p*-Value	n = 44	%	SD	*p*-Value	% Exp.	% Unexp.	% DID	*p*-Value
T01 Curiosity (biomass)	72	72.7	0.9	41	77.4	0.8	0.441	34	77.3	0.8	0.562	4.6	4.6	−0.1	0.564
T02 Comfort (biomass)	41	41.4	1	28	52.8	1	0.147	25	56.8	1	0.092	15.4	11.4	4.0	0.098
T03 Hunger (biomass)	11	11.1	0.3	5	9.4	0.3	0.745	6	13.6	0.3	0.681	2.5	−1.7	4.2	0.684
T04 Play (biomass)	42	42.4	1	26	49.1	1	0.439	31	70.5	0.9	0.002	28.0	6.6	21.4	0.003
T05 Hoard (biomass)	49	49.5	1	30	56.6	1	0.44	40	90.9	0.6	<0.001	41.4	7.1	34.3	0.003
T06 Status (biomass)	56	56.6	1	19	35.9	1	0.012	23	52.3	1	0.686	−4.3	−20.7	16.4	0.694
T07 Affiliate (biomass)	19	19.2	0.8	9	17.0	0.8	0.737	20	45.5	1	0.003	26.3	−2.2	28.5	0.006
T08 Fear (LPG)	85	85.9	0.7	37	69.8	0.9	0.038	17	38.6	1	<0.001	−47.2	−16.1	−31.2	0.008
T09 Status (LPG)	47	47.5	1	35	66.0	0.9	0.022	36	81.8	0.7	<0.001	34.3	18.6	15.8	0.004
T10 Disgust (paraffin)	75	75.8	0.4	36	67.9	0.5	0.317	42	95.5	0.2	<0.001	19.7	−7.8	27.5	0.005
T11 Comfort (LPG)	78	78.8	0.8	39	73.6	0.9	0.559	37	84.1	0.7	0.447	5.3	−5.2	10.5	0.449
T12 Fear (paraffin)	78	78.8	0.4	45	84.9	0.4	0.345	43	97.7	0.2	<0.001	18.9	6.1	12.8	0.005
T13 Affiliation (LPG)	47	47.5	0.5	20	37.7	0.5	0.249	38	86.4	0.3	<0.001	38.9	−9.7	48.6	0.008

a Significant differences at $\alpha = 0.05$.

Curiosity motivations linked to biomass stoves targeted by the first touchpoint (T01 in Table 4) showed an unreliable result. Changes in comfort motivations linked to improved biomass stoves (T02 in Table 4) were insignificant. Hunger motivations linked to improved biomass stoves (T03 in Table 4) showed an insignificant response to the intervention. The implementation showed an increase in play motivations linked to biomass stoves (T04 in Table 4) by 21.4% ($p = 0.003$). After adjusting for the baseline prevalence, the intervention increased hoarding motivations (T05 in Table 4) linked to biomass stoves by 34.3% ($p = 0.003$). After adjusting for the baseline prevalence, the status motivations linked to the biomass stoves (T06 in Table 4) result was unreliable. Affiliation motivations linked to biomass stoves (T07 in Table 4) increased significantly by 28.5% ($p = 0.005$). Fear motivations linked to LPG stoves decreased significantly (T08 in Table 4) by 31.2% ($p = 0.008$). Status motivations linked to LPG stoves (T09 in Table 4) increased significantly

by 15.8% (p = 0.004). The intervention significantly increased disgust motivations linked to paraffin stoves (T10 in Table 4) by 27.5% (p = 0.005). No significant changes in comfort motivations linked to LPG stoves (T11 in Table 4) were recorded. The implementation significantly increased fear linked to paraffin stoves (T12 in Table 4) by 12.8% (p = 0.005). Changes in motivations of affiliation linked to LPG stoves (T13 in Table 4) showed a significant increase of 48.6% (p = 0.008) post-campaign.

5. Discussion

Growing evidence suggests that behavioural design approaches can contribute to disseminating improved flame-based cookstoves at scale. The results of this study indicate that the application of selected aspects of a BCD approach could assist in understanding and influencing the critical cookstove-related motivations of South African households, leading to the increased adoption of improved cookstove alternatives.

A key finding indicates that intervention campaigns accommodating motivation-linked touchpoints could significantly increase the use of improved stoves. Respondents changed their stove-linked motivations to improve stove options when exposed to the piloted intervention.

The structured observations of cookstove ownership in the sample area confirmed that exposure to the pilot implementation increased the adoption of improved flame-based cookstoves, specifically, an increase in the ownership of biomass and LPG stoves. The card-based survey administered in the sample indicated a revaluation of cookstove-related motivations targeted in the co-created intervention. When exposed to the selected touchpoints, the change in observed cookstove ownership and differences in motivation-linked stove preferences confirmed the intervention's efficacy in influencing the adoption of flame-based cookstoves.

Despite the study being limited to a South African sample area, the sample selection criteria were based on the main factors that households using inefficient cookstoves exhibit, implying a broader relevance in the findings. The study may have important implications beyond disseminating clean and efficient cookstoves. Behavioural design approaches could significantly assist the development of behaviour change programmes in addressing the complex challenges affecting low- and middle-income households. The centrality of a primary behavioural goal informed by a deep understanding of the stove-linked motivations and their inclusion in co-created interventions has far-reaching implications. This more profound understanding of cookstove-related motivations is predicated on using integrated behavioural design approaches at the outset of SDG-focused interventions. The study demonstrates that the valuable role of a well-structured BCD approach can enhance the success of interventions aimed at behavioural changes.

In conclusion, provided that a desirable, available, affordable, improved cookstove infrastructure is in place, a behaviour-focused intervention inculcating the critical motivations for flame-based cooking can lead to the increased adoption and use of cleaner and safer cooking technologies with clear health benefits.

Author Contributions: Conceptualisation, M.M.; methodology, M.M.; investigation, M.M.; resources, M.M.; data collection, M.M.; supervision, M.K.M. and A.C.; funding acquisition, A.C. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study received ethical approval from the research ethics committee of the Cape Peninsula University of Technology (CPUT) (FID REC2017/03/02). Written informed consent was sought from all study participants following an explanation of study procedures. All methods were performed in accordance with the Declaration of Helsinki and all relevant regulations.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The supporting data can be obtained by contacting the corresponding author. All data will be shared upon reasonable request and with the permission of the original data source.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

To following flame-based cookstoves were available during the case study in 2017. The stoves using paraffin, LPG, and biomass available during the case study, as depicted in Figure A1, are discussed. Coal-fired stoves are excluded.

Traditional Fireplace	
	Low-cost traditional flame-based cooking method
	Biomass
	Cooking, water heating and partial space heating
	R0–R120 (including tripod)
	R0–R280

(**a**)

Imbaula Cookstove	
	Improvised self-constructed metal drum stove
	Biomass or coal
	Cooking, water heating and space heating
	R0–R140 (self-constructed)
	R0–R280

(**b**)

Panda Stove (legal version)	
	Low-cost, poorly constructed, unpressurised, wick stove
	Paraffin
	Cooking, water heating and partial space heating
	R120–R200
	R330

(**c**)

Panda Paraffin Heater	
	Dual-use, portable, low-cost, paraffin heater and cooker
	Paraffin
	Space heating, partial cooking and Water heating
	R350–R1239
	R260

(**d**)

Protostar Bhubezi Cookstove	
	Improved liquid fuel stove
	Methanol
	Cooking, water heating and partial space heating
	R400
	R135–R315

(**e**)

CleanCook Cookstove	
	Improved liquid fuel stove
	Ethanol or methanol
	Cooking, water heating and partial space heating
	R1100
	R90 per hob

(**f**)

Mbaula Green Cookstove	
	Improved solid fuel stove
	Biomass or coal
	Cooking, water heating and partial space heating
	R450
	R0–R280

(**g**)

EcoZoom Versa Stove	
	Improved solid fuel stove
	Biomass or coal
	Cooking, water heating and partial space heating
	R505
	R0–R280

(**h**)

Figure A1. *Cont.*

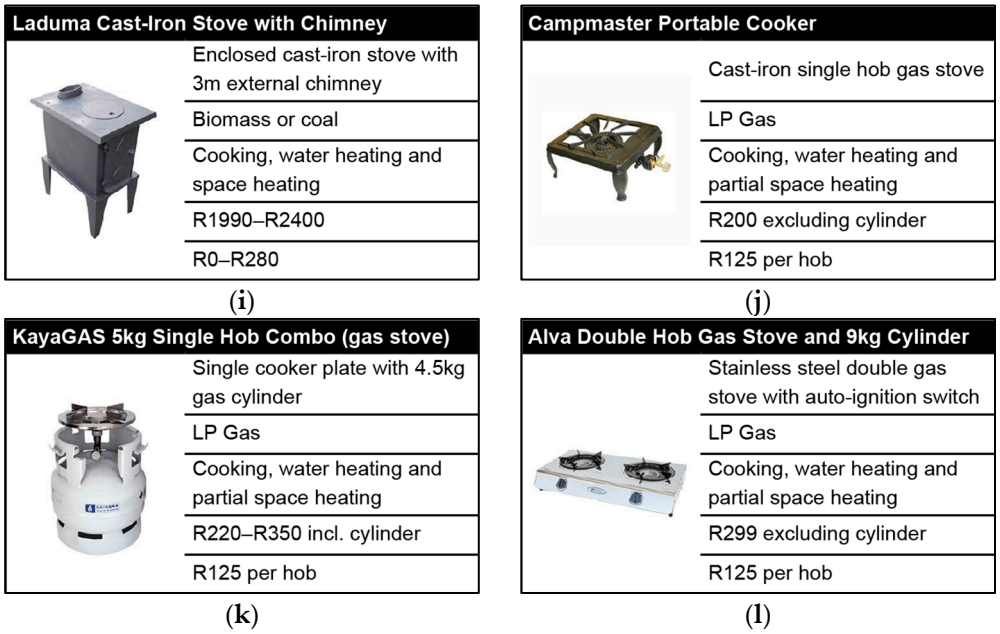

Figure A1. Locally available flame-based cookstoves and selected improved flame-based alternatives (including brand name, description, fuel type, use cases, stove cost and average fuel cost per month): (**a**) traditional fireplace; (**b**) imbaula cookstove; (**c**) Panda stove (legal version); (**d**) Panda paraffin heater; (**e**) Protostar Bhubezi cookstove; (**f**) CleanCook cookstove; (**g**) Mbaula Green cookstove; (**h**) EcoZoom Versa stove; (**i**) Laduma cast-iron stove with chimney; (**j**) Campmaster portable cooker; (**k**) KayaGAS 5 kg single hob combination gas stove; (**l**) Alva double-hob gas stove and 9 kg cylinder. Adapted from [62,85].

References

1. WHO. Household Energy (Database). Available online: https://www.who.int/data/gho/data/themes/air-pollution/who-household-energy-db (accessed on 15 February 2023).
2. IEA. *SDG7: Data and Projections*; IEA: Paris, France, 2022; Available online: https://www.iea.org/reports/sdg7-data-and-projections (accessed on 15 February 2023).
3. Pailman, W.; de Groot, J.; Clifford, M.; Jewitt, S.; Ray, C. Experiences with Improved Cookstoves in Southern Africa. *J. Energy S. Afr.* **2018**, *29*, 13–26. [CrossRef]
4. Lindgren, S.A. Clean Cooking for All? A Critical Review of Behavior, Stakeholder Engagement, and Adoption for the Global Diffusion of Improved Cookstoves. *Energy Res. Soc. Sci.* **2020**, *68*, 101539. [CrossRef]
5. Van Niekerk, A.; Kimemia, D.K.; Seedat, M.; Annegarn, H. Energy Impoverishment and Burns: The Case for an Expedited, Safe and Inclusive Energy Transition in South Africa. *S. Afr. J. Sci.* **2022**, *118*, 13148. [CrossRef] [PubMed]
6. Walls, R.S.; Eksteen, R.; Kahanji, C.; Cicione, A. Appraisal of Fire Safety Interventions and Strategies for Informal Settlements in South Africa. *Disaster Prev. Manag. Int. J.* **2019**, *28*, 343–358. [CrossRef]
7. Makonese, T.; Ifegbesan, A.P.; Rampedi, I.T. Household Cooking Fuel Use Patterns and Determinants across Southern Africa: Evidence from the Demographic and Health Survey Data. *Energy Environ.* **2018**, *29*, 29–48. [CrossRef]
8. Allorto, N.L.; Wall, S.; Clarke, D.L. Quantifying Capacity for Burn Care in South Africa. *Burn. Open* **2018**, *2*, 188–192. [CrossRef]
9. Kimemia, D.K.; Van Niekerk, A. Cookstove Options for Safety and Health: Comparative Analysis of Technological and Us-ability Attributes. *Energy Policy* **2017**, *105*, 451–457. [CrossRef]
10. Makonese, T.; Bradnum, C.M. Design and Performance Evaluation of Wood-Burning Cookstoves for Low-Income Households in South Africa. *J. Energy S. Afr.* **2018**, *29*, 1–12. [CrossRef]
11. Shackleton, C.; Sinasson, G.; Adeyemi, O.; Martins, V. Fuelwood in South Africa Revisited: Widespread Use in a Policy Vacuum. *Sustainability* **2022**, *14*, 11018. [CrossRef]
12. Barnes, B.R.; Mathee, A.; Thomas, E. The Impact of Health Behaviour Change Intervention on Indoor Air Pollution Indicators in the Rural North West Province, South Africa. *J. Energy S. Afr.* **2011**, *22*, 35–44. [CrossRef]
13. Makonese, T.; Masekameni, D.M.; Annegarn, H.J.; Forbes, P.B.C. Influence of Fire-Ignition Methods and Stove Ventilation Rates on Gaseous and Particle Emissions from Residential Coal Braziers. *J. Energy S. Afr.* **2017**, *26*, 16. [CrossRef]
14. Walls, R.; Kahanji, C.; Cicione, A.; van Vuuren, M.J. Fire Dynamics in Informal Settlement "Shacks": Lessons Learnt and Appraisal of Fire Behavior Based on Full-Scale Testing. In Proceedings of the Asia-Oceania Symposium on Fire Science and Technology, Taipei, Taiwan, 22–24 October 2018; pp. 15–27.

15. Department of Mineral Resources and Energy. *Annual Performance Plan for 2022–2023*; Department of Mineral Resources and Energy: Pretoria, South Africa, 2022; pp. 3–16.
16. Goodwin, N.J.; O'Farrell, S.E.; Jagoe, K.; Rouse, J.; Roma, E.; Biran, A.; Finkelstein, E.A. The Use of Behaviour Change Techniques in Clean Cooking Interventions to Achieve Health, Economic and Environmental Impact: A Review of the Evidence and Scorecard of Effectiveness. *J. Health Commun.* **2015**, *20*, 43–54. [CrossRef] [PubMed]
17. Furszyfer Del Rio, D.D.; Lambe, F.; Roe, J.; Matin, N.; Makuch, K.E.; Osborne, M. Do We Need Better Behaved Cooks? Re-viewing Behavioural Change Strategies for Improving the Sustainability and Effectiveness of Cookstove Programs. *Energy Res. Soc. Sci.* **2020**, *70*, 101788. [CrossRef]
18. Lambe, F.; Carlsen, H.; Jürisoo, M.; Weitz, N.; Atteridge, A.; Wanjiru, H.; Vulturius, G. *Understanding Multi-Level Drivers of Behaviour Change*; Stockholm Environment Institute: Stockholm, Sweden, 2018; pp. 4–24.
19. Lambe, F.; Ran, Y.; Jürisoo, M.; Holmlid, S.; Muhoza, C.; Johnson, O.; Osborne, M. Embracing Complexity: A Transdisciplinary Conceptual Framework for Understanding Behavior Change in the Context of Development-Focused Interventions. *World Dev.* **2020**, *126*, 104703. [CrossRef]
20. Dieye, A.M. Experimentation and Behaviour Change for the SDGs: Bringing Behavioural Insights to Scale. Available online: https://www.undp.org/content/undp/en/home/news-centre/speeches/2018/experimentation-and-behaviour-change-for-the-sdgs.html (accessed on 29 October 2020).
21. Jürisoo, M.; Lambe, F.; Osborne, M. Beyond Buying: The Application of Service Design Methodology to Understand Adoption of Clean Cookstoves in Kenya and Zambia. *Energy Res. Soc. Sci.* **2018**, *39*, 164–176. [CrossRef]
22. Lockton, D.; Harrison, D.; Stanton, N.A. Exploring Design Patterns for Sustainable Behaviour. *Des. J.* **2013**, *16*, 431–459. [CrossRef]
23. Aunger, R.; Curtis, V. Behaviour Centred Design: Towards an Applied Science of Behaviour Change. *Health Psychol. Rev.* **2016**, *10*, 425–446. [CrossRef]
24. Niedderer, K.; Clune, S.; Ludden, G. *Design for Behaviour Change: Theories and Practices of Designing for Change*; Routledge: London, UK, 2017; ISBN 9781317152521.
25. Goodwin, N. The Role of Behaviour Centred Design in Creating Value to Sustain Impact of Social Marketing: Evidence and Experience from Indonesia, Timor-Leste and Bangladesh. In *Proceedings of the Conference Proceedings from the International Social Marketing Conference, Singapore, 15–17 July 2018*; Hay, R., Ed.; MDPI: Basel, Switzerland, 2018; pp. 121–124.
26. Briscoe, C.; Aboud, F. Behaviour Change Communication Targeting Four Health Behaviours in Developing Countries: A Review of Change Techniques. *Soc. Sci. Med.* **2012**, *75*, 612–621. [CrossRef]
27. Rhodes, E.L.; Dreibelbis, R.; Klasen, E.M.; Naithani, N.; Baliddawa, J.; Menya, D.; Khatry, S.; Levy, S.; Tielsch, J.M.; Miranda, J.J.; et al. Behavioral Attitudes and Preferences in Cooking Practices with Traditional Open-Fire Stoves in Peru, Nepal, and Kenya: Implications for Improved Cookstove Interventions. *Int. J. Environ. Res. Public Health* **2014**, *11*, 10310–10326. [CrossRef]
28. Strömberg, H.; Selvefors, A.; Renström, S. Mapping out the Design Opportunities: Pathways of Sustainable Behaviour. *Int. J. Sustain. Constr. Eng. Technol.* **2015**, *8*, 163–172. [CrossRef]
29. Greenland, K.; Chipungu, J.; Curtis, V.; Schmidt, W.-P.; Siwale, Z.; Mudenda, M.; Chilekwa, J.; Lewis, J.J.; Chilengi, R. Multiple Behaviour Change Intervention for Diarrhoea Control in Lusaka, Zambia: A Cluster Randomised Trial. *Lancet Glob. Health* **2016**, *4*, 966–977. [CrossRef] [PubMed]
30. Aunger, R.; Curtis, V. *A Guide to Behaviour Centred Design*; London School of Hygiene & Tropical Medicine: London, UK, 2015; ISBN 9781584888161.
31. Clatworthy, S. Service Innovation through Touch-Points: Development of an Innovation Toolkit for the First Stages of New Service Development. *Int. J. Des.* **2011**, *5*, 15–28.
32. Aunger, R. Cultural Transmission and Diffusion. In *Encyclopedia of Cognitive Science*; Nadel, L., Ed.; Wiley: Hoboken, NJ, USA, 2003; pp. 1–6, ISBN 9780470018866.
33. Aunger, R.; White, S.; Huberts, J.; Greenland, K.; Curtis, V. *Behaviour Centred Design: Formative Research Protocols*; London School of Hygiene and Tropical Medicine: London, UK, 2017; Volume 1.1, pp. 5–64.
34. Coetzee, R. *The South African Culinary Tradition*; S.A. Library for the Blind: Grahamstown, South Africa, 1987; ISBN 869770837.
35. Gokee, C.; Logan, A.L. Comparing Craft and Culinary Practice in Africa: Themes and Perspectives. *Afr. Archaeol. Rev.* **2014**, *31*, 87–104. [CrossRef]
36. Steyn, P. Changing Times, Changing Palates. In *Cultivating the Colonies: Colonial States and Their Environmental Legacies*; Ax, C.F., Brimnes, N., Jensen, N.T., Oslund, K., Eds.; Ohio University Press: Athens, OH, USA, 2011; Volume 12, pp. 214–236, ISBN 9780824831615.
37. Chastanet, M.; Chouin, G.; de Lima, D.; Guindeuil, T. Towards a History of Foodways in Africa before the 20th Century. *Afriques* **2014**, *5*, 1–8. [CrossRef]
38. Osseo-Asare, F. *Food Culture in Sub-Saharan Africa*; Greenwood Publishing Group: Westport, CT, USA, 2005; ISBN 9780313324888.
39. Creswell, J.W.; Creswell, J.D. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*; SAGE Publications: New York, NY, USA, 2018; pp. 220–318, ISBN 9781506386683.
40. Reitsma, L.; Smith, A.; Van Den Hoven, E. Storybeads: Preserving Indigenous Knowledge through Tangible Interaction Design. In Proceedings of the 2013 International Conference on Culture and Computing, Culture and Computing, Kyoto, Japan, 16–18 September 2013; pp. 79–85.

41. Akintan, O.B.; Jewitt, S.; Clifford, M. Culture, Tradition, and Taboo: Understanding the Social Shaping of Fuel Choices and Cooking Practices in Nigeria. *Energy Res. Soc. Sci.* **2018**, *40*, 14–22. [CrossRef]
42. Trefry, A.; Parkins, J.R.; Cundill, G. Culture and Food Security: A Case Study of Homestead Food Production in South Africa. *Food Secur.* **2014**, *6*, 555–565. [CrossRef]
43. Sellick, W. *The Imperial African Cookery Book: Recipes from English-Speaking Africa*; Jeppestown Press: London, UK, 2010; ISBN 9780955393686.
44. Lloyd, P. The Energy Profile of a Low-Income Urban Community. In Proceedings of the Twenty-Second Domestic Use of Energy, Cape Town, South Africa, 1–2 April 2014; IEEE Xplore: Piscataway, NJ, USA, 2014; Volume 25, pp. 80–85.
45. Tait, L.; Merven, B.; Senatla, M. *Investigating the Current and Future Roles of Paraffin in South Africa*; Energy Research Centre, University of Cape Town: Cape Town, South Africa, 2012; pp. 14–44.
46. Buthelezi, S.A.; Kapwata, T.; Wernecke, B.; Webster, C.; Mathee, A.; Wright, C.Y. Household Fuel Use for Heating and Cooking and Respiratory Health in a Low-Income, South African Coastal Community. *Int. J. Environ. Res. Public Health* **2019**, *16*, 550. [CrossRef]
47. Matsika, R.; Erasmus, B.F.N.; Twine, W.C. Double Jeopardy: The Dichotomy of Fuelwood Use in Rural South Africa. *Energy Policy* **2013**, *52*, 716–725. [CrossRef]
48. De Chastonay, A.; Bugas, M.; Soni, S.; Swap, R. Community Driven Development of Rocket Stoves in Rural South Africa. *Int. J. Serv. Learn. Eng. Humanit. Eng. Soc. Entrep.* **2012**, *7*, 49–68. [CrossRef]
49. Kojima, M.; Bacon, R.; Zhou, X. *Who Uses Bottled Gas? Evidence from Households in Developing Countries*; World Bank: Washington, DC, USA, 2011. [CrossRef]
50. Kizilcec, V.; Perros, T.; Bisaga, I.; Parikh, P. Comparing Adoption Determinants of Solar Home Systems, LPG and Electric Cooking for Holistic Energy Services in Sub-Saharan Africa. *Environ. Res. Commun.* **2022**, *4*, 072001. [CrossRef]
51. Tatham, G.; Managing Director, KayaGAS (Pty) Ltd., Cape Town, South Africa. Personal communication, 6 June 2013.
52. Bowd, R.; Quinn, N.W.; Kotze, D.C.; Guilfoyle, M.J. A Systems Approach to Risk and Resilience Analysis in the Woody-Biomass Sector: A Case Study of the Failure of the South African Wood Pellet Industry. *Biomass Bioenergy* **2018**, *108*, 126–137. [CrossRef]
53. Petrie, B. South Africa: A Case for Biomass? OneWorld Sustainable Investments and IIED: London, UK, 2014; ISBN 9781784310721.
54. Wolpe, P.; Makhabane, M.; Jska de Groot, J. *A Feasibility Study and an Implementation Plan of Alternative Energy Technology Options for Unelectrified Informal Settlements in Gauteng Province*; Gauteng Department of Agriculture and Rural Development: Johannesburg, South Africa, 2015; pp. 23–119.
55. Tatham, G. Providing Gas to Poor Households in Greater Cape Town. In Proceedings of the 21st Domestic Use of Energy Conference (DUE), Cape Town, South Africa, 3–4 April 2013; IEEE: Piscataway, NJ, USA, 2013; pp. 1–3.
56. BRC. *The Establishment Survey—October 2017 Final Release*; The Broadcast Research Council of South Africa: Johannesburg, South Africa, 2017; pp. 12–65.
57. Langschmidt, P. New SEM Socio-Economic Segmentation Tool Explained. *Strateg. Mark.* **2017**, *8*, 32–34.
58. Stats SA. *General Household Survey 2014*; Statistics South Africa: Pretoria, South Africa, 2015.
59. Stats SA. *Men, Women, and Children: Findings of the Living Conditions Survey 2014/15*; Statistics South Africa: Pretoria, South Africa, 2018; pp. 36–49.
60. Yin, R.K. *Case Study Research and Applications: Design and Methods*; SAGE Publications: New York, NY, USA, 2017.
61. Kar, A.; Zerriffi, H. From Cookstove Acquisition to Cooking Transition: Framing the Behavioural Aspects of Cookstove Interventions. *Energy Res. Soc. Sci.* **2018**, *42*, 23–33. [CrossRef]
62. Maré, M.; Annegarn, H.J. The Use of Willingness to Pay in Determining Customer Preferences for Improved flame-based Cookstove Features in Two South African Study Areas. *Soc. Mark. Q.* **2017**, *24*, 335–353. [CrossRef]
63. Ramaekers, M.G.; Luning, P.A.; Ruijschop, R.M.A.J.; Lakemond, C.M.M.; Bult, J.H.F.; Gort, G.; van Boekel, M.A.J.S. Aroma Exposure Time and Aroma Concentration in Relation to Satiation. *Br. J. Nutr.* **2014**, *111*, 554–562. [CrossRef]
64. Evans, W.D.; Johnson, M.; Jagoe, K.; Charron, D.; Young, B.N.; Rahman, A.S.M.M.; Omolloh, D.; Ipe, J. Evaluation of Behavior Change Communication Campaigns to Promote Modern Cookstove Purchase and Use in Lower Middle Income Countries. *Int. J. Environ. Res. Public Health* **2017**, *15*, 11. [CrossRef] [PubMed]
65. Makonese, T.; Masekameni, D.M.; Annegarn, H.J. Energy Use Scenarios in an Informal Urban Settlement in Johannesburg, South Africa. In Proceedings of the 2016 International Conference on the Domestic Use of Energy (DUE), Cape Town, South Africa, 1–6 March 2016; IEEE Xplore: Cape Town, South Africa, 2016.
66. Barnes, B.R.; Mathee, A.; Thomas, E. Household Energy, Indoor Air Pollution and Child Respiratory Health in South Africa. *J. Energy S. Afr.* **2009**, *20*, 4–13. [CrossRef]
67. Harold, G.T.; Leve, L.D.; Barrett, D.; Elam, K.; Neiderhiser, J.M.; Natsuaki, M.N.; Shaw, D.S.; Reiss, D.; Thapar, A. Biological and Rearing Mother Influences on Child ADHD Symptoms: Revisiting the Developmental Interface between Nature and Nurture. *J. Child Psychol. Psychiatry* **2013**, *54*, 1038–1046. [CrossRef]
68. Lusinga, S.; de Groot, J. Energy Consumption Behaviours of Children in Low-Income Communities: A Case Study of Khayelitsha, South Africa. *Energy Res. Soc. Sci.* **2019**, *54*, 199–210. [CrossRef]
69. Van der Kroon, B.; Brouwer, R.; van Beukering, P.J.H. The Impact of the Household Decision Environment on Fuel Choice Behavior. *Energy Econ.* **2014**, *44*, 236–247. [CrossRef]

70. Bikombo, B.G. Understanding Household Food Insecurity and Coping Strategies of Street Traders in Durban. Master's Thesis, University of South Africa, Pretoria, South Africa, 2014.
71. Chirwa, P.W.; Ham, C.; Stella, M.; Balmer, M. Bioenergy Use and Food Preparation Practices of Two Communities in the Eastern Cape Province of South Africa. *J. Energy S. Afr.* **2010**, *21*, 26–31. [CrossRef]
72. Viljoen, A.T. *The Meaning of the Food Practices of the Peoples of Mmotla, Near Pretoria, South Africa: A Socio-Cultural and Socio-Psychological Approach*; PhD Consumer Science (Food Management), University of Pretoria: Pretoria, South Africa, 2010.
73. Hamerman, E.J. Cooking and Disgust Sensitivity Influence Preference for Attending Insect-Based Food Events. *Appetite* **2016**, *96*, 319–326. [CrossRef] [PubMed]
74. Kimemia, D.K.; van Niekerk, A.; Govender, R.; Seedat, M. Burns and Fires in South Africa's Informal Settlements: Have Approved Kerosene Stoves Improved Safety? *Burns* **2018**, *44*, 969–979. [CrossRef] [PubMed]
75. Beltramo, T.; Blalock, G.; Levine, D.I.; Simons, A.M. Does Peer Use Influence Adoption of Efficient Cookstoves? Evidence from a Randomized Controlled Trial in Uganda. *J. Health Commun.* **2015**, *20*, 55–66. [CrossRef] [PubMed]
76. Ardrey, J. Cookstoves and Health, a View from the Foot of the Energy Ladder: A Qualitative Study of a Cookstove Intervention in Rural Malawi. Ph.D. Thesis, The University of Liverpool, Liverpool, UK, 2016.
77. Altarriba Bertran, F.; Wilde, D.; Berezvay, E.; Isbister, K. Playful Human-Food Interaction Research: State of the Art and Future Directions. In Proceedings of the Annual Symposium on Computer-Human Interaction in Play, Association for Computing Machinery, New York, NY, USA, 22–25 October 2019; pp. 225–237.
78. Nuwarinda, H. Air Pollution Study of a Highveld Township during a Basa Njengo Magogo Rollout. Master's Thesis, University of Johannesburg, Johannesburg, South Africa, 2010.
79. Matinga, M.N.; Clancy, J.S. Gender, Firewood and Health: The Potential of Ethnography to Inform Policy and Practice. In *Engendering the Energy Transition*; Clancy, J.S., Ed.; Springer International Publishing: Cham, Switzerland, 2020; pp. 33–57, ISBN 9783030435127.
80. Ojong, V.B.; Ndlovu, J. "She Does Not Want to Cook for Me": Zulu Women and Food Preparation at the Crossroads of Courtship and Dating. *Agenda* **2016**, *30*, 36–45. [CrossRef]
81. Mor, Y.; Warburton, S.; Winters, N. Participatory Pattern Workshops: A Methodology for Open Learning Design Inquiry. *Res. Learn. Technol.* **2012**, *20*, 163–175. [CrossRef]
82. Kwon, K.J. INCOkit: A Toolkit to Support Internal Collaboration for Service Design Teams. Master's Thesis, Aalto University School of Arts, Design and Architecture, Helsinki, Finland, 2016.
83. Segelström, F. Visualisations in Service Design. Ph.D. Thesis, Department of Computer and Information Science, Linköping University, Linköping, Sweden, 2010.
84. Dziegielewski, S.F. In Vision Concept Cards: A Visual Tool for Addressing Life's Choices, Challenges and Changes. *Soc. Work Ment. Health* **2011**, *9*, 485. [CrossRef]
85. Sustainable Energy Africa. *Sustainable Energy Solutions for South African Local Government: A Practical Guide*; SEA: Cape Town, South Africa, 2017; pp. 3–17.