BERKELEY AIR MONITORING GROUP

Evaluation of Clean Cooking Behavior Change Communication Interventions

SUMMARY REPORT

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Executive Summary

From 2016-2019, the Clean Cooking Alliance (Alliance) selected and supported four behavior change communication (BCC) interventions in Bangladesh, Kenya, and Nigeria with funding from the Department for International Development of the United Kingdom. The program aimed to pilot established BCC techniques to enhance demand for cleaner household cookstoves and fuels. Together, the campaigns reached over 13 million people using a mix of radio, print advertising, TV programming, social media, and interpersonal communications. The campaigns are summarized below and in Table 1.

- The Social Marketing Corporation and Purplewood (SMC/Purplewood) aimed to increase the awareness, uptake, and use of metal biomass stoves and LPG by associating them with aspects of modernity in peri-urban and rural areas of **Bangladesh**.
- The Mediae Company (Mediae) sought to increase knowledge and awareness of how to finance, buy, and use cleaner and more efficient cookstoves through a reality TV and radio show that reached widely across **Kenya**.
- Population Services Kenya (PS Kenya) conducted an umbrella advertising campaign to build awareness and adoption of cleaner cookstoves and fuel, while also supporting partner organizations' promotional campaigns in several urban centers in **Kenya**.
- Africare and McCann Global Health (Africare/McCann) focused on motivating women to switch to LPG for cooking and use it safely in urban and peri-urban areas of Abuja and Lagos, **Nigeria.**

Coincident with the roll-out of the BCC campaigns, the Alliance also funded the impact evaluation that is the subject of this report. **The assessment examined the effects of the four BCC interventions on the purchase of modern cooking stoves and fuels[1] and changes in determinants of behavior, such as knowledge, attitudes, beliefs, and intentions.** A key objective was to determine the extent to which any changes in behavior could be attributed to the BCC interventions and to establish if there is a dose-response relationship between higher exposure to BCC messaging and the determinants of the desired behavior. A secondary aim of the evaluation was to model, where possible, the potential impact of scaled-up BCC activities on the Alliance's key mission areas of health, environment, livelihood, and gender. A complete list of research questions is provided on page 7.

Due to the real-world nature of the assessment, the evaluation team could not design a study that compared outcomes in participants randomly assigned to treatment and control groups. Instead we relied on **a quasi-experimental design featuring a dose/response index to compare participants based on levels of exposure to the BCC interventions.** We hypothesized that due to the variety of BCC techniques being implemented and to natural variation in people's media access, cookstove purchase and pre-purchase outcomes would also differ across the study population. Both self-reported exposures, collected from surveys in a random sample of the target population (n= 550 to 900 households), and exogenous data, such as on the size and location of TV, radio, and social media audiences, were used to estimate the BCC "dose" received. Changes in behavior, constituting the response to the dose, were

[1] The term "modern stoves and fuels" was used to encompass a range of commercially available energy-efficient wood and charcoal stoves, as well as assorted liquid petroleum gas (LPG) burners and fuel containers. Other fuels and stove types, such as biogas and ethanol, were promoted as applicable.

measured using a range of qualitative and quantitative methods including household surveys, in-depth interviews, focus group discussions, and sensor-based stove use monitoring. Due to evolution of the BCC implementations (detailed in annex 1), multiple study design adaptations were required (see overview of final design and timing of data collection in Table 2).

Although this report also provides descriptive data on study samples and details of observed changes between baseline and endline measurements, **the key findings on the effectiveness of BCC interventions in enhancing demand for and use of cleaner cookstoves and fuels are the results of multivariable logistic regression models.** Top-line conclusions from this analysis, which controlled for the impact of other factors on the observed changes in the target populations before and after the BCC campaigns, are presented below and detailed in Tables 5-8.

- Independent of other factors, exposure to the BCC materials **increased awareness of cleaner cooking options** (as promoted by each BCC campaigns) **25-fold in the SMC/Purplewood sample, and quadrupled awareness in both the Mediae and PS Kenya samples.** In contrast, the Africare/McCann sample had nearly 100% awareness of LPG prior to the BCC campaign and thus no potential for a positive effect of campaign exposure.
- BCC exposure **doubled intention to purchase** an LPG stove in the next month in the Africare/McCann peri-urban sample. There was no observed impact among other samples.
- There was **suggestive evidence of an impact on 1) purchasing an LPG stove, and 2) increasing LPG use** during the exposure period in the Africare/McCann samples.

In summary, there was evidence of effectiveness in achieving intended outcomes across the four BCC intervention projects: the **BCC boosted awareness and in some cases intention to purchase,** with suggestive or **negligible impacts on actual purchase** of promoted stoves or increased use of LPG. The outcomes reflect the multiple steps involved in the purchase pathway: the transition from ignorance to awareness through changed knowledge and attitudes to consideration prior to actual purchase and use.

In multivariable analyses, we also observed specific, statistically significant dose-response effects of the Mediae, Africare/McCann, and SMC/Purplewood BCC interventions on the outcomes noted above.

The evaluation's secondary aim to model potential climate or health impacts of the BCC interventions was not achieved because an insufficient number of purchasers of the promoted technologies/fuels were detected in our samples. Given its real-world context, the evaluation was limited by external factors including unexpected changes to BCC channels and messaging, shifts in energy- policies, and competing advertising. Furthermore, all the BCC interventions targeted lower income families who face liquidity constraints and often report that replacing their cookstove is not a priority.

In conclusion, it is worth revisiting the fact that BCC interventions of this scale have not previously been implemented in the cookstove sector. The current evaluation was similarly a new effort and thus both study results and lessons learned from the interventions should be treated as large-scale pilots that will inform future efforts. Still, given the scale of need for cleaner cooking technologies (3 billion people still rely on biomass, kerosene, and coal), BCC efforts that move the needle even modest amounts for large populations could have meaningful climate and health implications

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1 Purpose and Aims

The primary goal of this project was to evaluate the effects of four behavior change interventions on the purchase of modern cooking stoves and fuels[2] and changes in determinants of behaviors, such as knowledge, attitudes, beliefs, and intentions. Funded by the Clean Cooking Alliance (Alliance)[3] in 2016, the interventions used behavior change communications (BCC) that aimed to accelerate clean cooking markets by increasing awareness and adoption of cleaner, more efficient cooking solutions that are designed to reduce the health and environmental impacts of solid fuel and kerosene use.

The four BCC intervention projects were designed and implemented with support and guidance from the Alliance by four different organizations (or in some cases a partnership of two organizations). Table 1 outlines the aims, approaches, and geographies of each project.

Table 1: Overview on the four BCC implementation projects.

Location	Aim	BCC Channels and Key Themes	Dates Estimated reach
Implementing organization: The Social Marketing Company (SMC) and Purplewood			
Bangladesh. *Peri-urban/rural areas of the Dhaka and Barisal divisions.*	To increase awareness, uptake, and use of modern metal biomass stoves and LPG. To promote the benefits associated with the concept of a 'modern kitchen', while simultaneously increasing knowledge of the detrimental impacts of traditional cooking practices.	Interpersonal communication (IPC) via both one-on-one and group courtyard sessions combined with out of home (OOH) activities such as street theater, billboards and cookstove fairs. Targeting both men and women, the campaign used a storyline to reinforce the idea that a 'modern man' would help and support his family by purchasing a cleaner cookstove.	Aug 2017 – Aug 2018 1.6 million people
Implementing organization: The Mediae Company (Mediae)			
Kenya. *Urban, peri-urban, and rural areas.*	To increase the knowledge and awareness of the benefits of cleaner, more efficient cookstoves. To educate on where to buy clean(er) cooking options and how to finance them. To promote improved nutrition for the family.	The Mediae campaign featured the Shamba Chef TV & radio show which focused on clean cooking and nutrition. 13 episodes promoted a range of fuels and technologies and featured home make overs and competitions. In addition to social media, the viewers could also subscribe to a free interactive mobile platform called iChef to access more information.	Sept – Dec 2017 5 million people
Implementing organization: Population Services, Kenya, (PS Kenya), with technical input from Practical Action.			

[2] The term "modern stoves and fuels" was used to encompass a range of commercially available energy-efficient wood and charcoal stoves, as well as assorted liquid petroleum gas (LPG) burners and fuel containers. Other fuels and stove types, such as biogas and ethanol, were promoted as applicable.
[3] Formerly the Global Alliance for Clean Cookstoves

Location	Aim	BCC Channels and Key Themes	Dates Estimated reach
Kenya. *Urban and peri-urban areas of Greater Nairobi, Central, and Western Kenya.*	To use an "umbrella" campaign to create awareness and adoption of 'cleaner cookstoves and fuel' paired with a promotional campaign of three cleaner, more efficient charcoal stoves.	In addition to a radio campaign, the BCC employed a mix of approaches via sales driven as well as BCC focused organizations. Channels and settings included households, workplaces, community gatherings, and markets.	Mar 2017 – Aug 2018 2.8 million people
Implementing organization: Africare and McCann Global Health (Africare/ McCann)			
Nigeria. *Urban and peri-urban areas of Abuja and Lagos State.*	To motivate women to make the switch to LPG for cooking by promoting it as the 'Smarter, Better, Faster' way to cook. A secondary aim was to promote the safe use of LPG.	The 'Upgrade to Gas' campaign included a five-part, web-based mini-series, radio adverts / jingles, and social media campaign combined with door to door IPC and community outreach events.	Aug 2017 – May 2018 4 million people

Please see https://www.cleancookingalliance.org/market-development/demand-creation/campaign/index.html for further detail on each project.

A secondary aim of the evaluation was to model, where possible, the potential impact of scaled-up BCC activities on the Alliance's key mission areas of health, environment, livelihood, and gender.

The evaluation sought to answer several broad research questions. These questions framed the study design, measurement, and implementation of data collection. Specifically, we asked:

- Are the BCC interventions effective in motivating people to purchase and correctly use clean cooking technologies?
- To what degree can the changes in behavior be attributed to the BCC interventions?
- Is there a dose-response relationship between higher exposure to cookstove messages and the outcomes of positive attitudes, intention to purchase, cookstove purchasing and correct stove usage?
- Were there aspects of the BCC intervention that were more effective than others?
- What are the impacts of the BCC interventions on relative progress towards health, environment, livelihood, and gender goals?

2 Methods

2.1 Study Design Overview

The evaluation employed a quasi-experimental design (QED). A QED is any research design that employs an experimental comparison not created through random assignment. In this case, we compared participants in the evaluation based on observed levels of exposure, or dosage, to the BCC interventions.

The underlying assumption of the evaluation framework is that levels of BCC exposure would vary by two main factors: 1) intervention strategy and medium of exposure; and 2) segments of the target populations due to different levels of access to various media channels. As a function of these two factors, the evaluation team hypothesized that cookstove utilization outcomes would also differ across the study population. This variation enabled us to create measures of BCC campaign exposure.

There were two overall types of exposure measures used in this assessment. The first type is recognition of various types of modern cookstove promotions specific to the intervention being delivered in the participant's location. This is a self-reported measure of exposure. The second type is an exogenous measure of exposure, meaning that it is not dependent on self-report, consisting of independent measures of media and messages delivered by the BCC interventions within the target area, such as data on the size of TV, radio, and social-media audiences in those locations. We describe these methods in detail below.

2.2 Data Collection: Methods, Sample Size, and Timing

A mixed method research design that implemented both quantitative and qualitative approaches was used to collect data over multiple time points. Multiple adaptations to the original study plan were required in order to respond to the actual BCC implementation (see appendix 1 for further information on changes in implementation and the associated adaptation to study plan). Due to these changes, the Africare/McCann evaluation in Nigeria is the only one where all methods were implemented. Table 2 outlines the timing of each round of data collection and final sample size for each.

Table 2: Data collection timing and sample sizes by evaluation project

BCC Project	SMC/Purplewood, Bangladesh		Mediae, Kenya		PS Kenya, Kenya		Africare/ McCann, Nigeria	
Implementation	Aug 2017 – Aug 2018		Sept-Dec 2017		Mar 2017- Aug 2018		Aug 2017 – April 2018	
DATA COLLECTION METHODS								
	Date	**n***	**Date**	**n**	**Date**	**n**	**Date**	**n**
Baseline rapid survey	April 2017	559	Jan 2017	854	Jan 2017	690	May 2017	822
Midline rapid survey							Dec 2017	815
Endline rapid survey	Nov 2018	907	Jan 2018	860	Oct[4] 2017	793	May 2018	804
Stove use monitoring							Feb-May 2018	125
In-depth interviews	Jan 2019	75	May 2018	150			June 2018	150
Focus group discussions (FGDs)							Nov 2018	1 male 1 female

*n= number of households except for the FGDs where the n refers to groups of 8-10 people. Most rapid survey interviews involved one person from the household but sometimes involved two when the cook was not involved in decision making for the home. See section 2.2.1 for more detail.

2.2.1 Rapid survey

For each evaluation study, a population-based rapid survey was conducted at baseline and either at one or two timepoints after the BCC intervention had begun (see Table 2 for more detail). Sample selection was designed to reflect the target audiences of the BCC campaign in terms of geography, socio-economic class, age of the cook, and fuel use patterns. Households were selected from these areas using a standard approach to avoid any bias or convenience sampling. (See supplementary information for detailed sampling procedures for each study.)

In all cases, the main participant was the family member who organized the home-keeping, ideally carried out most of the cooking, and was involved in the decision-making for larger household (HH) purchases. If the main participant was not involved in the decision-making, the main decision-maker was also interviewed.

Data was collected using mobile data collection technology, (ODK (https://opendatakit.org/), with built-in quality and consistency checks.

2.2.2 In-depth interviews

In-depth interviews (IDIs) were conducted as part of the SMC/Purplewood, Mediae, and Africare/McCann evaluations. Four groups of female participants were interviewed as part of the Mediae and Africare/McCann evaluations – purchaser, non-purchaser, exposed, and unexposed – using a series of exploratory open questions. The SMC/Purplewood IDIs were conducted with both male and female exposed participants only.

[4] This evaluation was conducted while the PS Kenya campaign was still on going. However, the PS Kenya endline study did not take place as planned and so only two rounds of data collection occurred. For simplicity this round of data collection is referred to as the endline.

Participants for the IDIs were drawn from three different sources depending on the study group and location:

1. Rapid survey sample (SMC/Purplewood, Mediae, Africare/McCann).
2. Sales lists provided by distributors of the promoted stoves in the study areas (Mediae).
3. Implementing organization's lists of households that had been visited by a behavior change IPC councilor (Africare/McCann).

The interview was extensively piloted, and the field team was provided with intensive training to ensure that a rich information dataset was collected.

2.2.3 Focus group discussions

Focus group discussions (FDG) were conducted as part of the Africare/McCann evaluation study only. Approximately six months after the implementation project ended, one male and one female FGD were conducted each with eight to ten participants. A discussion guide was prepared to gain a deeper understanding of the drivers behind the reported and measured patterns of behavior seen in the quantitative dataset, as well as to explore apparently inconsistent or ambiguous data.

2.2.4 Stove use monitoring

Sensor-based stove use monitoring systems (SUMS) were implemented as a method to objectively measure stove use patterns in the Africare/McCann evaluation study only.[5] SUMS measure temperature as a proxy indicator for the time a stove is in use. SUMS iButtons were placed on the promoted stoves plus all other working stoves in a total of 125 households, which included exposed and unexposed, purchaser and non-purchaser homes (see Figure 1). The resulting temperature profiles were then analyzed to determine the frequency and duration of stove use events for all household cooking devices.

Figure 1: Kerosene stove (left) and LPG (right) fit with a SUMS iButton (model DS1922T, Maxim, USA)

[5] Annex 1 provides more detail on why the McCann/Africare evaluation was the only one to include SUM.

2.3 Measures and Indicators

Multiple measures and metrics were used to quantify and understand the effectiveness of the BCC campaigns in changing the knowledge, attitudes, and practices within the target population to ultimately increase the purchase and correct use of the promoted stoves.

2.3.1 Measures of exposure and response

The effectiveness of the BCC interventions was assessed by characterizing exposure/response for each BCC activity separately and in combination.

Exposure data: Two types of exposure measures were collected: 1) self-reported experience of the campaigns, including recognition (by visual aid) and confirmed recall of messages and program-related terminology (e.g., taglines) and images; and 2) external independent tracking data from multiple sources to measure potential exposure to clean cooking messages at the community, online, and media-market levels (see section 2.3.4 for more detail on these exogenous measures).

Self-reported data were collected via the rapid surveys to measure recall and recognition (Southwell et al, 2002; Evans et al, 2012; Evans, 2016) of specific BCC messages delivered by each implementing team. A full catalogue of the BCC activities implemented was created, and questions were asked to capture participation/exposure to each type in the midline and endline surveys, as well as frequency of exposure and reaction/receptivity questions to assess immediate message response (e.g., was the cookstove message credible, likable, shared with friends, or otherwise acted on).

Accurate knowledge was pre-defined, so that responses to knowledge items could be dichotomized into accurate or inaccurate knowledge. At baseline, sources of current knowledge were also considered, including both sources of knowledge related to clean cooking, as well as levels of exposure to selected communication channels i.e., TV, radio, etc.

As the BCC activities could have created a community dialogue and increased positive social norms about clean cookstove use, we also asked about diffusion effects (i.e., exposed individuals communicating directly with others about clean cooking and cookstoves), including conversations the respondent had with community members about cooking, and their reactions and receptivity to these dialogues.

Response data: The main responses of interest were changes in knowledge, attitudes, and practices (KAP), including cookstove purchase(s), intentions, and actions taken related to household cooking, such as use of clean cooking fuels. The baseline rapid survey established baseline KAP related to the expected BCC messages, such as those related to cooking appliances, fuels, and perceived barriers to uptake and use of improved cookstoves stoves and fuels.

Post-implementation data collection aimed to understand the nature and magnitude of the changes and attribute them as far as possible to the BCC campaign. The rapid population-based surveys, and in most cases the IDIs, were used in addition to two FGDs. The implementation of a range of evaluation tools allowed for not only the assessment of the magnitude and frequency of the responses to the BCC campaign, but also for the exploration of the meaning and motivations behind these reactions.

2.3.2 Stove usage indicators

Self-reported stove use: Self-reported stove use was estimated using data from the rapid surveys. The survey data provided context and understanding of the promoted and other stove use patterns, including of any "adoption niche" (Ruiz-Mercado 2011), that had occurred.[6] Perception of the stoves' ability to meet the cooking needs of the household were collected from users, while barriers to uptake were explored with the non-purchasers.

Stove use monitoring: Self-reported stove use was validated by objective stove use monitoring in the Africare/McCann evaluation. This aimed to provide information on the extent to which households consistently and correctly used the promoted cookstoves and fuels and the manner in which they integrated them into their kitchen activity patterns. The presence and nature of stove stacking was explored, thus allowing for a measure of new stove uptake as well as for displacement of the previous cooking devices. The trends and cooking frequency were analyzed to understand usage drivers and characteristics.

2.3.3 Measure for modeling other impacts

We planned to estimate health, climate, and forestry impacts by using a combination of methods used by the WHO (Household Multiple Emissions Source model [HOMES]), Gold Standard Foundation (CO2 and black carbon offset methodologies), and leading forestry experts (Modeling Fuelwood Savings Scenarios [MoFuss]). To estimate impacts, these models rely on changes in emissions and fuel use associated with increased uptake or usage of cleaner burning technologies. As explained in the results (Section 3), and further explored in the discussion (Section 4), adequate changes in uptake and usage, which are fundamental to running those models, were not detected with this study, and therefore the models were not ultimately applied.

2.3.4 Exogenous measures

The exogenous BCC measures were independent, non-self-reported measures of the delivery of media and messages within certain intervention areas, including for both mass media and digital media. These measures were limited to media and messages delivered by the BCC interventions (not by commercial marketing). The two main types of exogenous variables were 1) reach and frequency measures of the audience for mass media (TV and radio) within specific geographic locations served by the BCC; and 2) social media reach and engagement metrics (e.g., likes, comments, shares on social media posts). The mass media data were available for the Africare/McCann, PS Kenya, and the Mediae campaigns. The SMC/Purplewood BCC campaign did not utilize these media channels.

2.3.5 Explanatory information

In-depth interviews were conducted to understand more deeply the nature of impact and effects of the BCC at a household level. Questions explored why some households moved to change their behavior

[6] An adoption niche refers to the role a given cookstove or fuel plays within the household energy portfolio based on its perceived best use by the user relative to the qualities of the other options.

either by purchasing a promoted stove or increasing use of a promoted fuel as well as the barriers that occurred for others.

2.4 Human Subjects Ethical Approvals

The study protocol was approved by the institutional review boards at Advarra (https://www.advarra.com/ protocol number Pro00022033). Local permission was also sought and secured as required in all three study countries. Informed and voluntary consent was obtained from all study participants for all data collection methods, including permission to audio record during FGDs and to take and use photographs.

2.5 Analysis

2.5.1 Rapid survey data

All rapid survey data collected for each BCC evaluation were analyzed in SAS 9.4 (Cary, NC, USA). Descriptive statistics summarized frequencies, percentages, means, and standard deviations (SD) of the study samples, including socioeconomics, demographics, stove behaviors, media use, and key variables for BCC exposures and outcomes.

To evaluate the independent impact of the BCC exposures on the primary outcomes, multivariable logistic regression models were utilized with dichotomous outcomes[7]. In brief, multivariable analysis is commonly used to assess the independent impact of an exposure on an outcome, while controlling for relevant factors (also called variables) that might also affect that outcome, such as age, sex, or socioeconomic status. In this analysis process, the evaluation team first identified any of these factors that were associated with the outcomes and exposures using unadjusted analyses. Factors with suggestive evidence of associations with the outcomes (i.e., p-value≤0.10) were then included in full multivariable logistic regression models to adjust for their potential effects. Reduced model iterations were explored by removing variables with the highest p-values and least impact on the model, while assessing changes in effect and precision of the exposure on the outcome.

Measures of exposures to the BCC campaigns included both the self-reported and, where available, the exogenous data noted earlier. In the multivariable models, several indicators were used to represent the range of possible sources of exposure: each individual BCC material separately; a summed exposure index to all BCC materials; and a sum of all sources of information related to improved cookstoves.

In some samples, such as the one for the Africare/McCann evaluation, population-level data capturing social media access were also assessed as an exposure. Data on the implemented social media campaign and responses to posts in the form of impressions generated and engagement metrics were used.

Final summaries of the adjusted logistic regression models for each outcome report odds ratios (OR), 95% confidence intervals (CI), and p-values. Please see annexes 3-6 for further detail on the variables included in each model.

[7] Dichotomous outcomes are those with only two possible choices, such as purchase vs no purchase or aware vs not aware.

2.5.2 Modeling Over Time

The multivariable models focused on a quantitative exposure index to capture BCC exposure rather than solely a time-point comparison. While comparing differences in outcomes of interest (e.g., knowledge, attitudes, and practices) between baseline and follow-up time points is useful, this is a crude proxy for what really mattered – differences between exposed and non-exposed groups. Therefore, when baseline data was available for an outcome of interest, the survey time point (baseline vs. follow-up) was included as a variable in the multivariable model. However, if there was no baseline data available, then the time point was not included in the model.

2.5.3 SUMs

Baseline cooking events were identified from iButton temperature traces using SUMSARIZER (sumsarizer.com), an online analysis tool developed specifically for the cookstove sector. The data files were uploaded to the web server, where segments from each data file were randomly selected for the analyst to review and manually label cooking events. Using the analyst's input, a machine learning algorithm then applied the patterns identified in the manually reviewed subset to the rest of the data files. The dataset of identified cooking events was then analyzed in R (RStudio, Inc. Version 3.0.1). Cooking events under 9 minutes in duration were removed from the analysis to increase the confidence that only true cooking events were being captured. Cooking events within 60 minutes of each other were grouped into single occurrences to account for refueling activity.

2.5.4 Qualitative data

Thematic analysis was carried out using NVivo 12 qualitative analysis software (QSR International, 2018) to synthesize and interpret all qualitative data. The transcripts of both IDIs and FGDs were initially reviewed by two members of the research team and a provisional coding frame created based on the research question and themes of interest. NVivo codes were added as unanticipated themes were introduced. Coding frames were continually reviewed by the analysis team for duplication and refined accordingly.

3 Results

The study results from the rapid surveys, SUM, IDIs, and FGDs are presented in five sections: the demographics of the study sample; simple comparisons of outcomes of interest pre- and post the BCC interventions; a more in-depth multivariable analysis of key outcomes that showed strong observed effects; the stove use monitoring data from Nigeria; and qualitative information collected through in-depth interviews and focus group discussions aimed at providing context for and explanation of the quantitative findings. Note that the following results section is a summary, and a full presentation of all results can be found in the annexes. These five sections are presented in a standard order that aims to build the reader's understanding of the study outcomes, beginning with descriptive and bi-variate analyses. The multivariable analysis provides the most robust evidence of the nature and magnitude of effects attributable to the BCC campaigns. When reading for statements about observed effects attributable to the campaigns, please refer to the multivariable results.

3.1 Rapid Survey Results

3.1.1 Descriptive statistics

Table 3 below summarizes the study sample characteristics for the four evaluation studies based on the last survey conducted[8]. More detailed descriptive statistics from all surveys including baseline and, if available, midline data are presented in Annex 3-6.

For the SMC/Purplewood evaluation, the respondents were peri-urban/rural lower-middle income residents from the central southern divisions of Dhaka (68%) and Barisal (32%). The main respondent was a married woman between the ages of 20-35 years. One-third of interviews also included her husband, when he was available and involved in making large household decisions. Educational levels of respondents were mostly some high school or less, few women had paid work outside the home, and most cared for an average-sized Bangladeshi household of 4.5 people. annex 3 provides further information on the socio-economic class of these selected participants.

At endline, the sample for the Mediae evaluation included respondents from urban (39%), peri-urban (47%), and rural areas (14%). The majority of respondents were married females between the ages of 23 and 50 who had some secondary school or higher education. Just over 60% of respondents had paid work outside the home at endline. In keeping with the BCC project's target audience, all households were within the low and lower middle-income socio-economic class as defined by the living standards measure (LSM)[9]. The average number of people eating an evening meal in the household, excluding infants, was 3.6 (SD 2) at both time points. Annex 4 provides further information on the socio-economic class of these selected participants.

The PS Kenya sample included both urban (82%) and peri-urban residents (18%). Ages ranged between 23-50 years old, and most respondents were female and had completed some secondary school or

[8] An endline survey was not carried out as part of the PS Kenya evaluation-- baseline and midline only. See the separate document annex 1 for more details.

9 http://www.integraafrica.com/index.php?q=con,7,SSA_LSM The LSM divides the population in to 17 LSM groups, 17 (highest) to 1 (lowest). For more information on the Mediae evaluation target population please see annex 4 and for more information on the PS Kenya evaluation target population please see annex 5.

higher (74%). Most were married (65%) and had paid work outside the home (61%). In keeping with the BCC project's target audience, all households were within the lower-middle to upper-middle income groups as defined by the LSM. The average number of people eating an evening meal in the household, excluding infants, was the same at both time points at 3.4 people (baseline SD 2.0, endline SD 1.8). annex 5 provides further information on the socio-economic class of these selected participants.

As significant differences were found in key characteristics between the Africare/McCann peri-urban and urban samples, the data was analyzed and presented separately. Most of the peri-urban sample for the Africare/McCann evaluation was drawn from Lagos State (87%), with the rest from Abuja City. The age of respondents was fairly evenly distributed between 18-40 years, and the majority of respondents were female (96%), married (86%). Education status of the primary wage earner was 71% with secondary school or higher. The average number of people eating an evening meal in the household, excluding infants, was 4.2-5.0 across the three time points (national average 4.9). Annex 6 provides further information on the socio-economic class of these selected participants.

The urban sample for the Africare/McCann evaluation had most respondents from Lagos State (88%). Age of respondents was mostly between 26-40 years, and the majority of respondents were female (94%) and married (86%). There were slightly more respondents of lower socioeconomic status (69%) than in the peri-urban group. Education status of the primary wage earner was 75% with secondary school or higher. The average number of people eating an evening meal in the household, excluding infants, was 4.2-5.7 across three time points. annex 6 provides further information on the socio-economic class of these selected participants.

Table 3. Endline sample characteristics of all interventions

	SMC/Purplewood (N=907) *Freq. (%)*	**Mediae** (N=860) *Freq. (%)*	**PS Kenya** (N=793) *Freq. (%)*	**Africare/McCann**	
				Peri-urban (N=437) *Freq. (%)*	**Urban** (N=367) *Freq. (%)*
Area of residence	Division Dhaka: 616 (68%) Barisal: 291 (32%)	Urban: 336 (39%) Peri-urban: 403 (47%) Rural: 121 (14%)	Urban: 647 (82%) Semi-urban: 146 (18%) Rural: 0 (0%)	Study site Lagos State: 380 (87%) Abuja City: 57 (13%)	Study site Lagos State: 322 (88%) Abuja City: 45 (12%)
Age group (years)	20-24: 234 (26%) 25-29: 285 (31%) 30-35: 388 (43%)	23-25: 266 (31%) 26-30: 230 (27%) 31-50: 364 (43%)	23-25: 294 (37%) 26-30: 203 (26%) 31-50: 296 (37%)	18-25: 84 (19%) 26-30: 128 (29%) 31-35: 105 (24%) 36-40: 120 (28%)	18-25: 66 (18%) 26-30: 96 (26%) 31-35: 90 (25%) 36-40: 115 (31%)
Education level	*Of Respondent* Primary or less: 397 (44%) Some HS: 372 (41%) HS or more: 138 (15%)	*Of Respondent* None through primary complete: 326 (38%) Some secondary or higher: 532 (62%)	*Of Respondent* None through primary complete: 208 (26%) Some secondary or higher: 585 (74%)	*Of Primary Earner* None through some secondary: 129 (30%) Secondary through some post-secondary: 213 (49%) Post-secondary or higher: 95 (22%)	*Of Primary Earner* None through some secondary: 89 (24%) Secondary through some post-secondary: 192 (52%) Post-secondary or higher: 86 (23%)

3.1.2 Observed changes in outcomes of interest

Primary outcomes of interest were compared based on pre- and post-exposure to the BCC campaigns. Table 4 focuses on outcomes related to the promoted stoves and/or fuels, including awareness of modern biomass stoves and LPG, positive attitudes, intention to purchase within a month, increased use of LPG within the past year, and actual purchase of biomass or LPG stoves within the BCC exposure period. Note that full outcomes and data from baseline and, where available, midline and endline are presented in annexes 3-6.

There was evidence of change between pre- and post-exposure to the BCC activities in several of the outcomes, as discussed below and displayed in Table 4. The extent to which these observed effects can be attributed to BCC activities is presented in the multivariable analysis in section 0.

- A modest increase was observed in awareness of improved biomass stoves between baseline and the follow up time points for the SMC/Purplewood, Mediae, and PS Kenya samples. In the Africare/McCann peri-urban and urban samples, nearly 100% of participants were aware of the benefits of LPG prior to the BCC campaign.
- Positive attitudes, measured as strong agreement with one or more questions about attitudes towards LPG stoves, increased in the Africare/McCann sample: peri-urban (from 37% to 59%) and urban (34% to 51%) samples.
- Intention to purchase a modern biomass stove in the next month was low across all study sites, with little change from baseline to endline.
- In the Africare/McCann evaluation, the fraction of people who increased LPG use or started using LPG was high among the small sub-group who reported changing their LPG use within the BCC exposure period (83% peri-urban, 80% urban), although it should be noted that this subgroup was too small to allow for measures of statistical significance.
- Purchase of an LPG stove within the BCC exposure period varied between studies: SMC/Purplewood (n=209, 39%), Mediae (n=25, 13%), PS Kenya (n=40, 20%), Africare/McCann peri-urban (n=42, 10%), and Africare/McCann urban (n=85, 23%). Percentages are based on reduced sample sizes of respondents who currently own an LPG stove.

Table 4. Primary outcomes comparing baseline and endline time points for all interventions.

	SMC/Purplewood		Mediae		PS Kenya		Africare/McCann			
							Peri-urban		Urban	
Outcome[1]	Baseline (N=559) Freq (%)	Endline (N=907) Freq (%)	Baseline (N=854) Freq (%)	Endline (N=858) Freq (%)	Baseline (N=690) Freq (%)	Midline (N=792) Freq (%)	Baseline (N=465) Freq (%)	Endline (N=437) Freq (%)	Baseline (N=357) Freq (%)	Endline (N=367) Freq (%)
Awareness of improved biomass stoves										
Yes	3 (0.5%)	141 (16%)	565 (66%)	610 (71%)	507 (73%)	624 (79%)	n/a[3]	n/a	n/a	n/a
No	552 (99%)	766 (84%)	289 (34%)	248 (29%)	183 (27%)	168 (21%)	n/a	n/a	n/a	n/a
Awareness of the benefits of LPG/gas stoves										
Yes	n/a	882 (97%)	n/a	596 (69%)	n/a	540 (68%)	459 (99%)	435 (99.5%)	357 (100%)	365 (99.5%)
No	n/a	25 (3%)	n/a	262 (31%)	n/a	252 (32%)	5 (1%)	2 (0.5%)	0 (0%)	2 (0.5%)
Positive attitudes towards improved stoves or modern stoves (among those who were aware of modern stoves)										
Minimal positive attitudes	n/a	391 (92%)	n/a	160 (26%)	n/a	303 (38%)	245 (63%)	164 (41%)	173 (66%)	155 (49%)
Greater positive attitudes	n/a	3 (8%)	n/a	447 (74%)	n/a	490 (62%)	141 (37%)	234 (59%)	89 (34%)	161 (51%)
Intention to purchase an improved stove within next month (among those that were aware of modern stoves)										
Yes, within next month	15 (11%)	73 (8%)	108 (19%)	59 (10%)	99 (20%)	90 (15%)	48 (13%)	17 (7%)	23 (11%)	31 (16%)
No	119 (89%)	834 (92%)	457 (81%)	549 (90%)	406 (80%)	529 (85%)	326 (87%)	238 (93%)	197 (90%)	165 (84%)
Increased use of LPG/started using LPG within past year (out of those who had changed their LPG use)										
Yes	n/a	24 (17%)	n/a	n/a	n/a	n/a	n/a	19 (83%)	n/a	20 (80%)
No	n/a	121 (83%)	n/a	n/a	n/a	n/a	n/a	4 (17%)	n/a	5 (20%)
Purchase an improved biomass stove within the BCC exposure period[2]. Follow up data only										
Yes		No purchase		1 (6%)		4 (25%)		n/a		n/a
No		No purchase		16 (94%)		12 (75%)		n/a		n/a
Purchase an LPG stove within the BCC exposure period [2] Follow up data only										
Yes		209 (39%)		25 (13%)		42 (20%)		42 (10%)		85 (23%)
No		329 (61%)		163 (87%)		165 (80%)		395 (90%)		282 (77%)

1 Sample sizes for each outcome varied based on missing values and filtering.

2 Percentages are based on reduced sample sizes of respondents who currently owned a improved biomass or LPG stove.

3 n/a shown where the data was not collected as it was not required for the original evaluation study aim or where the baseline questions were no longer a viable counterpart to follow-up data due to changes in the BCC implementation after the baseline survey. In the latter case baseline data is available in annexes 3-5

3.1.3 Multivariable analysis of effects attributable to the BCC campaigns

To assess the impact of the BCC campaigns on the primary outcomes, we conducted multivariable logistic regression models, which adjusted for one or more of the following variables: socioeconomic status, age, sex, education, stove use patterns, and media consumption. Please see annexes 3-6 for further detail on the variables included in each model. Tables 5-8 summarize the multivariable logistic regression results for selected outcomes and exposures across all interventions. Key assessment outcomes are presented below.

- Independent of other factors, exposure to the BCC materials increased awareness of cleaner cooking in options in the SMC/Purplewood sample by 25 fold, and quadrupled awareness in both the Mediae and PS Kenya samples of improved biomass stoves and LPG as promoted by the BCC campaigns (Table 5). In contrast, the Africare/McCann sample had an extremely high level of awareness of LPG (nearly 100%) prior to the BCC campaign and thus no potential for a positive effect of campaign exposure (data not shown).
- Exposure to the BCC campaign doubled intention to purchase an LPG stove in the next month in the Africare/McCann peri-urban sample, but there was no observed impact among other samples (Table 6).
- There was also suggestive evidence of an impact from BCC exposure and access to sources of modern cooking information on **1) purchasing an LPG stove, and 2) increasing LPG use** during the exposure period in the Africare/McCann peri-urban and urban samples, respectively, but again the campaign had no observed impact in the other samples (Table 7).
- In sum, it appears the BCC campaigns boosted awareness and in some cases intention to purchase, with suggestive or negligible impacts on actual purchasing of promoted stoves or increasing use of LPG.

Table 5. Multivariable logistic regression results for outcome: awareness of improved stoves promoted by BCC campaign.

Exposures of interest	SMC/Purplewood	Mediae	PS Kenya	Africare/McCann	
	(No. of observations used) Odds ratio (95% CI, p-value)[1]	(No. of observations used) Odds ratio (95% CI, p-value)[1]	(No. of observations used) Odds ratio (95% CI, p-value)[1]	Peri-urban (No. of observations used) Odds ratio (95% CI, p-value)[1]	Urban (No. of observations used) Odds ratio (95% CI, p-value)[1]
Total number of exposures to the BCC. zero exposures (ref) 1 one or more exposures	[Improved biomass] (N=892) 24.8 (12.8 to 47.9; p<0.0001)	[Improved biomass] (N=738) 4.4 (2.8 to 6.9; p<0.0001) [LPG] (N=738) 1.3 (0.9 to 1.9; p=0.21)	[Improved biomass] (N=791) 4.0 (2.6 to 6.1; p<0.0001) [LPG] (N=790) 1.6 (1.1 to 2.2; p=0.01)	*NOTE: nearly 100% of sample was aware of LPG, no variation in outcome.*	*NOTE: nearly 100% of sample was aware of LPG, no variation in outcome.*

[1] Full models were adjusted for the exposure of interest plus selected variables. These variables were chosen based on their crude associations with the outcome (p<=0.10). The adjusted effects of the exposure on the outcome did not vary in effect measure or precision based on inclusion or removal of these variables, therefore, the full models are presented.

Table 6. Multivariable logistic regression results for outcome: intention to purchase a stove as promoted by the BCC in the next month.

Exposures of interest	SMC/Purplewood	Mediae	PS Kenya	Africare/McCann	
	(No. of observations used) Odds ratio (95% CI, p-value)[1]	(No. of observations used) Odds ratio (95% CI, p-value)[1]	(No. of observations used) Odds ratio (95% CI, p-value)[1]	Peri-urban (No. of observations used) Odds ratio (95% CI, p-value)[1]	Urban (No. of observations used) Odds ratio (95% CI, p-value)[1]
Total number of exposures to the BCC. zero exposures (ref) 1 one or more exposures	*NOTE: reported descriptively due to low cell counts that don't warrant assessment with full multivariable models.*	[Modern biomass stoves] (N=601) 1.5 (0.8 to 2.9; p=0.25)	[Modern biomass stoves] (N=619) 1.0 (0.6 to 1.0; p=0.93)	[LPG] (N=992) 2.0 (1.1 to 3.6; p=0.002)	[LPG] (N=618) 1.5 (0.8 to 2.6; p=0.18)
Sum of all possible sources of information related to new stove marketing.[2] 1 source of information (ref) 2+ sources of information	*NOTE: reported descriptively due to low cell counts that don't warrant assessment with full multivariable models.*	[Modern biomass stoves] (N=1162) 0.6 (0.4 to 0.8; p=0.002)[3]	[Modern biomass stoves] (N=1122) 0.7 (0.5 to 1.0; p=0.04)[3]	[LPG] (N=989) 0.9 (0.6 to 1.3; p=0.52)	[LPG] (N=615) 0.9 (0.5 to 1.8; p=0.80)

[1] Full models were adjusted for the exposure of interest plus selected variables. These variables were chosen based on their crude associations with the outcome (p<=0.10). The adjusted effects of the exposure on the outcome did not vary in effect measure or precision based on inclusion or removal of these variables, therefore, the full models are presented.
[2]Filtered to those said were aware of 'modern stoves"?"
[3]Despite significance of p-value, odds radio (OR) not in the expected direction

Table 7. Multivariable logistic regression results for outcome: increased use of LPG or started using LPG in past year (among those that had changed their LPG use).

Exposures of interest	SMC/Purplewood	Mediae	PS Kenya	Africare/McCann	
	(No. of observations used) Odds ratio (95% CI, p-value)[1]	(No. of observations used) Odds ratio (95% CI, p-value)[1]	(No. of observations used) Odds ratio (95% CI, p-value)[1]	Peri-urban (No. of observations used) Odds ratio (95% CI, p-value)[1]	Urban (No. of observations used) Odds ratio (95% CI, p-value)[1]
Total number of exposures to the BCC. zero exposures (ref) 1 one or more exposures	(N=143) 1.5 (0.5 to 4.3; p=0.46)	[Aspiration to increase use of LPG more than currently used now] (N=229) 0.6 (0.3 to 1.2; p=0.16)	[Aspiration to increase use of LPG more than currently used now] (N=225) 0.8 (0.4 to 1.4; p=0.41)	[Purchase LPG and/or increase use within exposure period] (N=796) 1.7 (0.8 to 3.4; p=0.15)	[Purchase LPG and/or increase use within exposure period] (N=602) 1.3 (0.8 to 2.1; p=0.22)
Sum of all possible sources of information related to new stove marketing.[2] 1 source of information (ref) 2+ sources of information	*Unstable model due to low sample count (N=84) 1.7 (0.3 to 8.6; p=0.52)	[Aspiration to increase use of LPG more than currently used now] (N=188) 0.7 (0.3 to 1.4; p=0.28)	[Aspiration to increase use of LPG more than currently used now] (N=185) 0.8 (0.4 to 1.5; p=0.42)	[Purchase LPG and/or increase use within exposure period] (N=794) 0.9 (0.4 to 1.9; p=0.80)	Purchase LPG and/or increase use within exposure period] (N=711) 2.1 (1.3 to 3.4; p=0.001)

[1] Full models were adjusted for the exposure of interest plus selected variables. These variables were chosen based on their crude associations with the outcome (p<=0.10). The adjusted effects of the exposure on the outcome did not vary in effect measure or precision based on inclusion or removal of these variables, therefore, the full models are presented.
[2]Filtered to those said were aware of 'modern stoves"?"

Table 8. Multivariable logistic regression results for outcome: purchase of an improved stove as promoted by the BCC within exposure period.

Exposures of interest	SMC/Purplewood (No. of observations used) Odds ratio (95% CI, p-value)[1]	Mediae (No. of observations used) Odds ratio (95% CI, p-value)[1]	PS Kenya (No. of observations used) Odds ratio (95% CI, p-value)[1]	Africare/McCann Peri-urban (No. of observations used) Odds ratio (95% CI, p-value)[1]	Africare/McCann Urban (No. of observations used) Odds ratio (95% CI, p-value)[1]
Total number of exposures to the BCC. zero exposures (ref) 1 one or more exposures	[LPG] (N=528) 0.7 (0.5, 1.1; p=0.11)	[Modern biomass stove described descriptively due to low cell counts] [LPG] (N=176) 1.2 (0.4 to 3.4; p=0.78)	[Modern biomass stove described descriptively due to low cell counts] [LPG] (N=207) 1.6 (0.8 to 3.3; p=0.17)	*NOTE: outcome collapsed with increased use of LPG within exposure period (see Table 6).*	*NOTE: outcome collapsed with increased use of LPG within exposure period (see Table 6).*
Sum of all possible sources of information related to new stove marketing.[2] 1 source of information (ref) 2+ sources of information	[LPG] (N=273) 0.8 (0.5 to 1.4; p=0.45)	Modern biomass stove described descriptively due to low cell counts] [LPG] (N=150) 0.5 (0.1 to 1.6; p=0.23)	[Modern biomass stove described descriptively due to low cell counts] [LPG] (N=168) 0.7 (0.3 to 1.6; p=0.45)	*NOTE: outcome collapsed with increased use of LPG within exposure period (see Table 6).*	*NOTE: outcome collapsed with increased use of LPG within exposure period (see Table 6).*

1 Full models were adjusted for the exposure of interest plus selected variables. These variables were chosen based on their crude associations with the outcome (p<=0.10). The adjusted effects of the exposure on the outcome did not vary in effect measure or precision based on inclusion or removal of these variables, therefore, the full models are presented.
2Filtered to those said were aware of 'modern stoves"?"

3.2 Stove Use

Stove use monitoring measurements are presented here for the Africare/McCann evaluation. 17 peri-urban and 99 urban homes were sampled with SUMs, and the combined results are presented here, as no discernable difference between these groups' stove use patterns was observed. Figure 2 shows the average stove use events per day for all samples collected. Within the sample there were 101 kerosene, 86 LPG, 7 charcoal, and 2 electric stoves, with kerosene and LPG stoves having the highest use events per day.

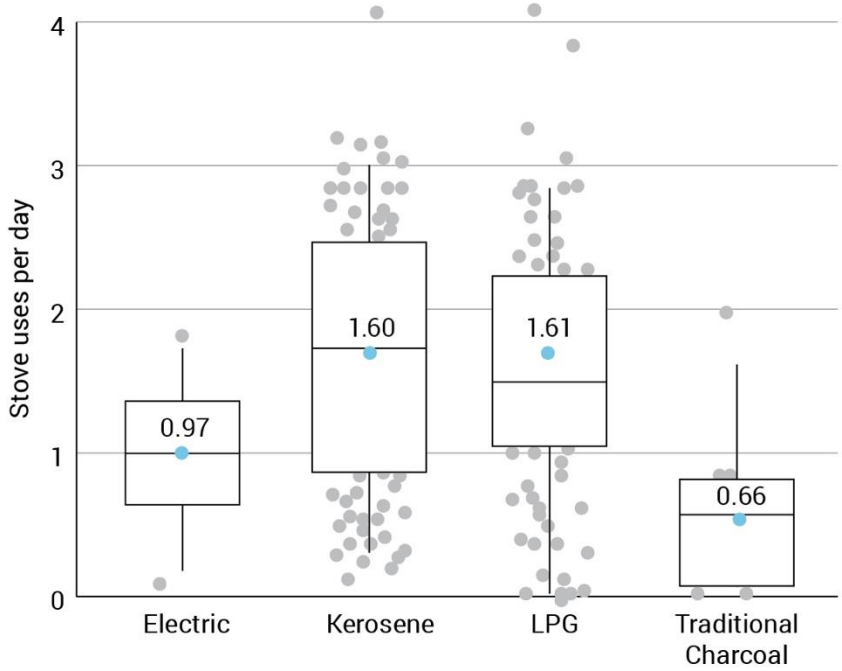

Figure 2. Box plots of use events per day for measured stoves in the Africare/McCann sample. The middle line represents the median, boxes encompass the inter-quartile range, and whiskers extend to the 5th and 95th percentiles. The blue diamond is the mean.

The graphics in Figure 3 show how dominant kerosene and LPG use was, constituting approximately 98% of all stove use events in the sample. Kerosene was the most commonly used fuel, suggesting that transition from kerosene to LPG still poses a substantial opportunity.

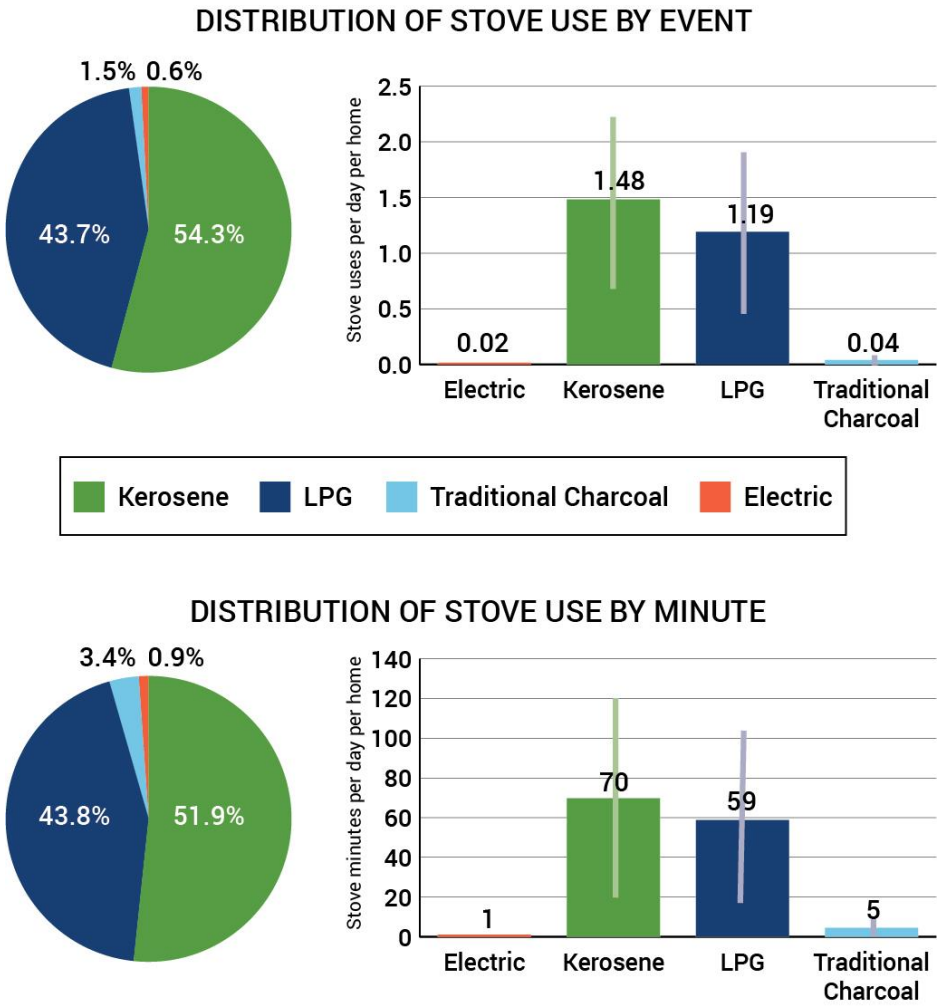

Figure 3. Distribution of stove use by event (top) and minutes shown in the bar graph and the usage per shown in the bar graph. Error bars represent the standard deviation.

Figure 4 shows the reported stove use by exposed and non-exposed groups. There was no clear pattern in differences between reported LPG use for exposed or unexposed across the different time points, although the multivariate modeling suggested a possible effect on LPG purchase and increased use when controlling for other variables. We did not find differences in uptake or usage of cleaner-cooking options associated with BCC exposures for the other projects, and the detailed reported use results can be found in annexes 3-6.

Reference lines for measured stove use have been added for context. Participants appeared to slightly overestimate total stove use compared to directly measured stove use (blue dashed line). Interestingly, the kerosene use was generally underestimated while LPG use was overestimated. The idea that LPG is considered a more aspirational fuel compared to kerosene may have influenced participants to overreport its use, though this is speculation. Further, caution should be taken in making these comparisons as the stove use monitoring subgroup was a relatively small sample, and thus the data is not directly comparable. Still, the trend is suggestive and aligns with the idea of LPG being a desirable fuel option.

The graph also suggests that the total stove use was higher in the exposed versus non-exposed group, though reasons for this difference are unclear.

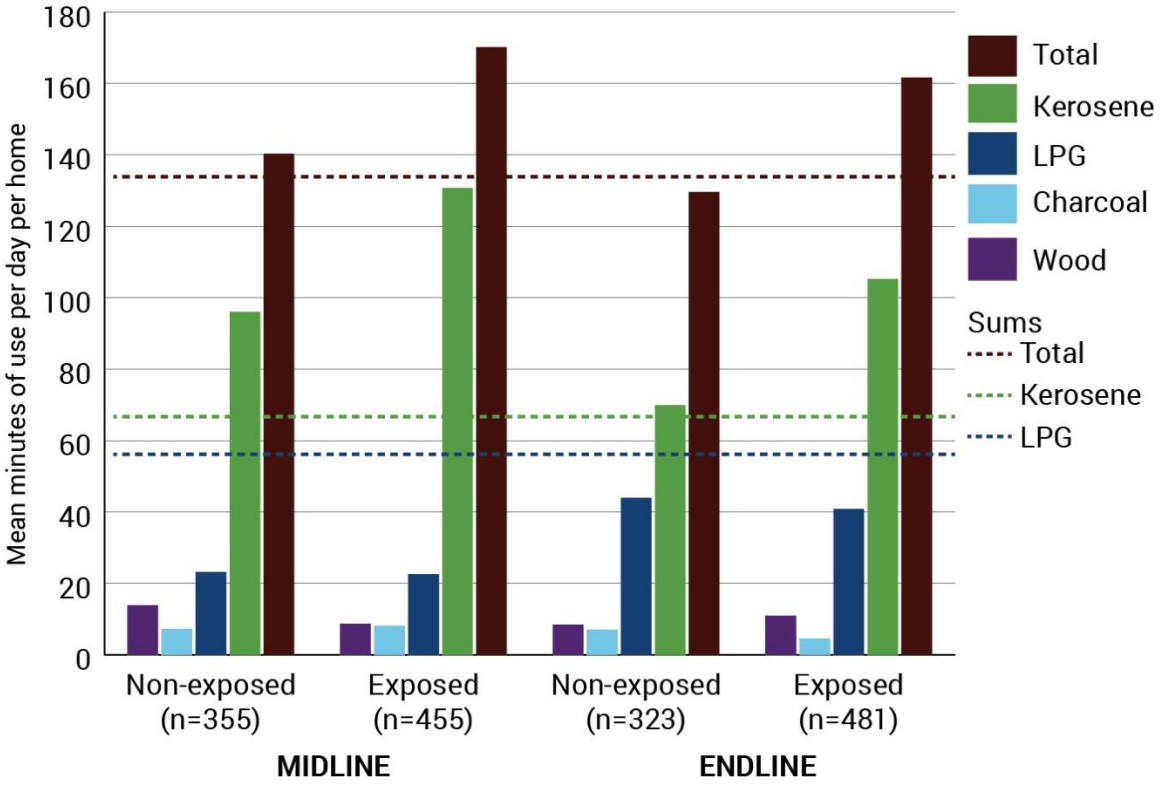

Figure 4. Reported stove use at midline and endline: Africare/McCann evaluation. Mean measured stove use via SUMS has been overlaid on the graph to provide comparison between the two methods

3.3 Qualitative Findings

The keys finding from the IDIs and FGDs are presented in Table 9 below. Several of the negative factors associated with traditional cooking, as well as the barriers to uptake and use of the promoted stoves and fuels presented here, were also reflected in the formative research conducted in the design phase of the BCC campaigns and leveraged in the key BCC messages. The section on 'impact of BCC' shows the ways in which the BCC worked to have an effect these issues.

Table 9: Overview of the qualitative data results.

SMC/Purplewood	Mediae	Africare/McCann
Awareness of and attitudes toward promoted stove/fuels		
Metal modern biomass: Level of awareness very low prior to the BCC. No attitudes yet developed due to lack of awareness. **LPG**: Prevalent but niche cooking fuel limited by cost. LPG is the aspirational fuel, and attitudes are positive. Some level of anxiety over fuel-associated hazards but less so than seen in Mediae and Africare/McCann samples.	**Modern biomass**: Levels of awareness high, with widespread positive attitudes. General knowledge of potential benefits is also high. Less often reported to be an aspirational stove than gas. **LPG**: Use, awareness, and desirability are widespread. Perceptions of LPG stoves are negatively influenced by anxiety over fuel-associated hazards but less than in Nigeria.	**LPG:** Awareness is very high. It is an aspirational stove, with widespread appreciation of its benefits. Some perception that it is a fuel for the 'rich'. There is a deep-rooted, ubiquitous fear of explosion, and many expressed an uncertainty on how to use the stove safety.
Barriers to uptake		
Modern biomass: Very low level of awareness, and no aspirational value. General satisfaction with current cooking method of traditional mud stove plus LPG, even though it is time-consuming. Traditional cookstoves often accommodate multiple pots, requiring multiple modern stoves to fully displace. Cooking habits on wood-burning stoves are deeply entrenched. **LPG:** Initial outlay is the main barrier. Fear of explosion is rarely a barrier to purchase.	Overall cookstoves are competing against other household items in liquidity-constrained HHs. **Modern biomass:** Initial cost of the stove. Value: Although many recognize the benefits of the modern biomass stoves, they are not convinced of the value proposition compared to traditional stoves. Lack of information on specific stoves. Increasing price of charcoal and decrease in reliable sources of woodfuel are pushing more people to consider gas. **LPG:** Initial outlay is the main barrier. Fear of explosion, particularly acute in HH with younger children.	**LPG:** Initial cost of the cylinder: many competing HH priorities puts LPG purchase behind school fees and everyday items, such as food and clothing. Fear of explosion, particularly acute in household with children under 12. Access to fuel: the weight of the cylinder means that women often need to rely on their male partner or a service for delivery. People carrying LPG cylinder are frequently denied access to public transport. Mistrust of vendors.

SMC/Purplewood	Mediae	Africare/McCann
Drivers to purchase		
Modern biomass: No HH in study sample had purchased. Potential push[10] factors: • Traditional stoves are seen as time consuming. • Cooking can be a dirty, smoky task particularly when using leaves as a fuel source. • Several HHs report a desire to change their cooking position to standing. **LPG** Pull factors**:** • Speed of cooking, convenience provided by ease of lighting for snacks and hot drinks, cleaner cooking. • Being able to cook in the main room of the house, particularly at night. Prestige symbol for visiting family and friends.	**Modern biomass:** Push factors: Desire to reduce smoke and ash. Pull factors: • Fuel efficiency and fuel savings. • Speed of cooking. • Ease, and/or convenience in stove use. • Modern stove with positive impacts on the family's health. **LPG:** The drivers for purchase of LPG stoves mirrored those for modern biomass stoves, but LPG was seen as superior in terms of ease and convenience, cleanliness, and modernity.	**LPG:** Push factor: Desire to move away from kerosene. It's difficult to light, blackens pots, and creates offensive odors. Pull factors: • Speed, ease, and/or convenience in stove use. A desire to 'eat on time' is a reoccurring theme. • Cleaner kitchen and kitchenware. A concept of modernity or elevated standard of living often influenced by peers and family.
Gender roles in stove purchase		
Overall the decision-making and purchasing processes are described as collaborative, however it is the men who have the final decision on whether, when, and what to buy. All women report that they could not buy without the male permission. Many do not have their own income: "*As she doesn't earn, she couldn't buy it even if she wished.*" The women usually initiate discussion of a new stove. The men will then permit purchase (or not), and they will go alone to buy the stove because the women would be at risk of being 'scammed' by the retailer.	Many women reported that they alone make the purchase decision -- spousal permission seemed to be less of a requirement than in the Africare/McCann and SMC/Purplewood samples. It was usually the women who chose the stove type and made the purchase. When men did become involved, they primarily contributed financially: "*… he topped up the amount I had saved."* When a woman had paid work outside the home or her own business, she was more likely to make independent decisions.	Overall the decision-making and purchasing processes are described as collaborative. Most women report needing their husband's permission to purchase a large HH item. Women usually initiate the conversation, and men are often the ones to actually purchase the stove, claiming that they get a 'better deal' than their wives. Several women report that their husbands prevent them from buying LPG due to safety concerns.

[10] In this case push factors refer to the characteristics of the traditional cooking technology which appear to be 'pushing' the participants towards the new cooking options. Pull factors are the characteristics of the new cooking technology that are encouraging their use.

SMC/Purplewood	Mediae	Africare/McCann
Impact of BCC		
IPC: Most of the women were introduced to improved biomass stoves by an IPC counselor. They could recall many of the messages, with health impacts of smoke being particularly prominent, memorable, and new. Women appreciated the potential benefits of a modern biomass stove but were not motivated to purchase because they: Did not have the financial capacity; Already had a gas stove and saw no need for another; Weren't interested: "*I like to cook on my old stove. I am used to cook in my mud stove.*" Some reported increasing their LPG use after seeing the IPC counselor, persuaded by reduced effort and health effects of smoke. Most men were not available to meet the IPC counselor. They stated that their wives did not discuss the meeting with them, and very few noticed any behavior change afterwards. **OOH / mass media:** Very few people reported to recall any campaign posters or community events. Some women reported that they do not leave the house and so could not be exposed through these channels.	**OOH/mass media:** Many of the exposed purchasers described how *Shamba Chef* influenced their decision to purchase a modern biomass stove. Many were actively considering purchase prior to watching the show, motivated by advertised faster cooking and fuel savings. Seeing the stove used on the show provided the affirmation of its benefits that was needed to trigger purchase. The women also felt reassured and empowered by the simple clear information on how to use the stoves. *Shamba Chef* was most influential with HHs that relied solely on traditional cooking methods but had minimal impact in persuading LPG owners to consider purchasing a modern biomass stove. Overall, the show was more likely to motivate purchase of modern biomass stove than the more ubiquitous gas. Possible reasons include: only 2 of 13 episodes featured gas stoves; LPG benefits are already well established; and the main barrier to LPG is liquidity constraints rather than lack of awareness or aspiration.	**IPC:** Overall the IPC counselors served to correct misconceptions and remove/diminish fears. Reduced fuel cost and ease of use were frequently recalled motivating messages. The imparted knowledge and skills seemed to empower the women and give the men increased confidence in their wives' ability to use LPG. Several men reported previously forbidding their wives to purchase but allowing it after IPC visit. The women appreciated the opportunity to ask questions in the one-on-one visit. The printed materials enabled them to share information with other HH decision-makers. **OOH / mass media:** People who heard the radio BCC were more motivated to purchase by the cost and ease-of-use arguments than by alleviated safety fears. Participants frequently reported that the radio BCC made people reconsider the customary perception that LPG is expensive to use and seek further information.

4 Discussion

4.1 Research Question Conclusions

Are the BCC interventions effective in motivating people to purchase and correctly use clean cooking technologies? To what degree can the changes in behavior be attributed to the BCC interventions?

We found evidence of effectiveness in achieving intended BCC outcomes across the four BCC intervention projects. The outcomes reflect the multiple steps involved in the purchase pathway: the transition from ignorance to awareness through changed knowledge and attitudes to consideration prior to actual purchase and use. Observed changes were seen in the majority of these outcomes, including increases in knowledge/awareness of modern cookstoves and their benefits, improvements in positive attitudes/beliefs, as well as intentions to purchase and use the promoted stoves and/or fuels. The only observed change in purchase and/or increased use of one of the promoted stoves or fuels attributable to the BCC was a weak effect on the purchase of and/or increased use of LPG in Nigeria.

Is there a dose-response relationship between higher exposure to cookstove messages and the outcomes of positive attitudes, intention to purchase, cookstove purchasing, and correct stove usage?

In multivariable analyses, we observed specific, statistically significant dose-response effects of the Mediae, Africare/McCann and SMC/Purplewood BCC interventions on the outcomes noted above. Self-report dose-response effects based on recognition of visual aids presented in the rapid survey were observed in each of these three BCC interventions. Effects varied across outcomes, but consistently included improvements in knowledge, attitudes/beliefs, intentions, and were robust in the multivariate models when controlling for demographics and local variables. For example, there was suggestive evidence that greater BCC exposure among the Africare/McCann samples was associated with increased knowledge and more positive attitudes towards LPG, stronger intention to buy LPG, and higher likelihood of having purchased and/or increased LPG use.

We also observed dose-response effects from the Mediae and Africare/McCann BCC based on exogenous measures. Mass media and social media exposure were associated with improvements in outcomes in the Africare/McCann evaluation. Mass media exposure was also associated with improvements in the Mediae project.

Please note, the evaluation team was unable to measure correct stove use for any of the improved biomass stoves[11] due to low penetration in the sample across all locations.

[11] Assessing correct usage of LPG stoves was not planned, as operator variability has minimal impact on LPG cookstove emissions.

Were there aspects of the BCC intervention that were more effective than others?

While it was possible to identify the BCC approach that yielded the most impact within each campaign, we could not make quantitative, statistical comparisons between them due to the diverse nature of the interventions. According to the rapid survey results presented in annexes 3-6, TV was more effective as a delivery channel than the radio broadcasts for Mediae's *Shamba Chef*. In contrast, PS Kenya's BCC radio programming was more effective than their printed materials. While the quantitative data did not identify a most effective channel in the Africare/McCann evaluation, the more targeted qualitative data collection revealed that the IPC counselors played a significant role in moving families to purchase. Due to the low level of reported exposure to aspects of the SMC/Purplewood BCC campaign other than IPC, it was not possible to make meaningful intra-campaign channel comparison.

What are the impacts of the BCC interventions on relative progress towards health, environment, gender, and livelihood goals?

We were not able to detect significant differences in improved stove and or/fuel uptake and adoption associated with the behavior change interventions, and therefore it was not possible to model any potential climate or health impacts due to increased use of the promoted technologies/fuels. Certainly, there could be climate or health impacts that we were not able to estimate, and even relatively small increases in uptake or use could have substantial impact as the target populations were large.

Much of the difficulty in detecting differences in increase in uptake of stoves and fuels, and therefore modeling climate and health impacts, was reflected in challenging market realities with both supply and demand for the given target geographies. All projects targeted low to lower-middle income families who face many competing demands for their limited funds and often report that replacing their cookstove is not a priority. In Kenya the baseline rate of promoted biomass stove ownership was very low (~3% in our sampled population), and therefore very large relative increases in uptake would have been needed to be able to detect a difference (e.g., a 100% increase in promoted stove sales would have raised the ownership rate to 6%). In the SMC/Purplewood evaluation, satisfaction with current cooking methods, a perceived inability to pay, and poor access to or knowledge of where to purchase the promoted biomass stoves proved to be significant obstacles. Respondents in the Africare/McCann evaluation cited fear of explosion, liquidity constraints, and distrust of vendors as barriers to uptake and/or increased LPG use.

4.2 Study Design Strengths and Limitations

A key strength of the evaluation was the collection of similar data across the four BCC interventions, using a largely standardized rapid survey and analogous qualitative instruments, and following parallel sampling methodologies (in terms of drawing representative samples tied to the BCC areas and target audiences). These were successfully implemented, demonstrating a suite of methods that may be applied in future cross-site cookstove BCC evaluations.

Another strength of the evaluation was the pairing of robust quantitative data from relatively large random samples with qualitative methods that were able to dig deeper into the motivations and perspectives of individual households. In three of the evaluations, we used a mixed method sequential explanatory

approach whereby qualitative data are used to deepen the understanding of the quantitative results. This technique was especially useful in exploring the impacts of IPC on target households because the random sampling did not capture many of these homes. In the case of the Africare/McCann evaluation, the research team were able to identify the key components of the IPC that triggered behavior change – in this case reducing barriers related to LPG safety concerns -- from the qualitative data rather than the quantitative results.

Broadly, the quasi-experimental study design was both a strength and limitation of this evaluation. On the one hand, conducting a natural real-world evaluation brought into sharp focus the actual barriers to purchasing modern household energy faced by lower income families, particularly affordability, safety concerns, and lack of access. To know if BCC has a valuable role to play in household energy transitions, we must evaluate it in this unforgiving reality. On the other hand, a limitation of this study was that the BCC program activities were particularly difficult to align with the evaluation. Challenges included last-minute changes to the BCC channels and messaging, unexpected shifts in energy-related government policies, “noise” in the marketplace from other campaigns, and steep affordability barriers to the target population acquiring the promoted stoves and fuels. While some of these circumstances where beyond anyone’s control, actionable recommendations include conducting each BCC campaign in its own geographically distinct area and pairing BCC activities more intentionally with financing mechanisms.

There were a number of important limitations to each evaluation. First, the SMC/Purplewood evaluation had a long delay in the launch of the BCC implementation, which led to one evaluation timepoint (midline) being dropped and a long delay (18 months) between the baseline and endline data collection reducing comparability of the data. Additionally, there was a lack of supply of the promoted biomass stoves and associated pellet fuel, such that most of the target population could not access them. Further, this situation caused the BCC implementers to make significant changes to their campaign mid-stream.

In the PS Kenya study, we observed that the BCC messages and materials were not well distinguished from on-going commercial stove marketing and advertising that were being executed concurrently in the intervention region. This situation possibly led rapid survey respondents to attribute PS Kenya messages to TV advertising even though these were actually delivered through printed materials. Therefore, self-report exposure measures related to printed materials were rendered ineffective at detecting dosage. Additionally, the limited locations and variability of potential exposure to radio spots made it impossible to employ exogenous measures of media exposure in the outcome analysis.

The main limitation for the Mediae evaluation was that the planned second season of the TV show was not produced. This cancellation truncated the evaluation and prevented us from observing any potential acceleration of outcomes or long-term changes. Additionally, the 2017 presidential election caused the airing of the first season of *Shamba Chef* to be delayed, leading to a larger than planned interval between baseline and follow-up, which potentially impacted on the comparability of the data.

There were some changes in the location of implementation of the Africare/McCann BCC that necessitated changes in sampling in peri-urban areas. The adjustment in samples by urban/peri-urban location affected our ability to make comparisons based on similarly sized samples between these locations over time. A further limitation was the last-minute cancellation of television advertising as the

centerpiece of the BCC campaign and a resulting unforeseen emphasis on IPC activities, which were challenging to assess with our study design.

Overall, while there were changes in attitudes and intentions -- important proximal outcomes of any BCC campaign -- across the projects towards cleaner stoves and fuels, substantive barriers to their acquisition rendered estimating their associated health and climate benefits unachievable. Still, given the scale of need for cleaner cooking technologies (3 billion people still relying on biomass, kerosene and coal), behavior change efforts that do move the needle even modest amounts for large populations could have meaningful climate and health implications. This is one strength of BCC efforts – that small effects can result in large population level improvements, as noted in the literature (Evans 2014, Wakefield 2014).

In conclusion, it is worth revisiting the fact that BCC interventions of this scale have not previously been implemented in the cookstove sector. The current evaluation was similarly a new effort and thus both study results and lessons learned from the interventions should be treated as large-scale pilots that will inform future efforts. Despite a number of challenges, the evaluation generated valuable programmatic learnings, both in this report, its supporting annexes, and in materials produced by the BCC teams. It is hoped that future studies will be able to anticipate and control for some of the highlighted exogenous factors that can impact the evaluation of BCC interventions in the cookstove sector in order to design future rigorous experiments.

5 References

Evans, W. D., Wallace, J. L., & Snider, J. (2012). Pilot evaluation of the text4baby mobile health program. BMC public health, 12(1), 1.

Evans, W. D. (2016). Social marketing research for global public health: methods and technologies. New York: Oxford University Press.

Ruiz-Mercado, I., Masera, O., Zamora, H., & Smith, K. R. (2011). Adoption and sustained use of improved cookstoves. Energy Policy, 39(12), 7557–7566. http://doi.org/10.1016/j.enpol.2011.03.028

Southwell, B. G., Barmada, C. H., Hornik, R. C., & Maklan, D. M. (2002). Can we measure encoded exposure? Validation evidence from a national campaign. Journal of Health Communication, 7(5), 445-453.

Wakefield, M.A., Loken, B., Hornik, R. C., (2014) Use of mass media campaigns to change health behaviour. Lancet, 376 (9748): 1261-1271. doi: 10.1016/S0140-6736(10)60809-4

6 List of Supporting Annexes

1. Chronology of Study Design Changes
2. Method and Instrument Detail
3. SMC/Purplewood Detailed Results
    A. Quantitative rapid survey summary
    B. Qualitative data summary
4. Mediae Detailed Results
    A. Quantitative rapid survey summary
    B. Qualitative data summary
5. Population Services Kenya Detailed Results
    A. Quantitative rapid survey summary
6. Africare/McCann Detailed Results
    A. Quantitative rapid survey summary
    B. Qualitative data summary
    C. Technical brief: Impact on safe use of LPG
7. Time Use Data- SMC/Purplewood and Africare/McCann
8. Macro Environment During BCC Implementation and Evaluations
9. Summary Results PowerPoint Presentation