THE UNIVERSITY
of NORTH CAROLINA
at CHAPEL HILL

Poverty Effects of Cookstoves
Baseline Report

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Carolina Population Center
University of North Carolina at Chapel Hill
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Our acknowledgments would be incomplete without mentioning our team of very able research assistants in Gisenyi. Specifically, we acknowledge the input of the team of supervisors and enumerators, whose dedication during data collection ensured that the data collected were of high quality.

The patience exercised by the Rwandan households during interviews is also greatly acknowledged. It is our hope that the insights from the information that they provided will translate into valuable interventions in their communities.

Executive Summary

This document provides basic information and summary statistics of a major assessment of the Inyenyeri Clean Cook Stove Model currently being rolled out in Gisenyi town, Western Rwanda. The assessment is based on a randomized encouragement design. Households in Gisenyi were first randomly sampled for selection into the study sample (N=1462). Two-thirds of this sample were then randomly assigned to receive a home visit from an Inyenyeri sales staff to learn about the stove. Baseline data was collected in 2015, and a follow-up will be conducted in 2019, as Inyenyeri rolls out its cook stove model to households in the city of Gisenyi. A sub-sample of 180 households, two-thirds from the encouragement group, were selected for more detailed exposure monitoring (EM), including stove-use monitoring, personal exposure of PAH and CO, and area monitoring. This sub-sample will be further measured in 2016 and 2017 and at the overall study endline.

Households were administered a multi-topic household survey icovering all aspects of the household economy, including consumption expenditures, time-use, health for all members, and preferences. A unique aspect of the study is that a range of individual measures were separately collected for the main cook. In this sample, 34 percent of main cooks are employees, adding an additional novel aspect to the study design.

The main study aims are to estimate the impact of the Inyenyeri cook stove model on exposure to airborne contaminants and to individual health of main cooks, and to assess the impact of the cook stove on fuel expenditures, poverty and time-use. The main data collection and analysis for this study is funded by the National Institute of Environmental Health Sciences (NIEHS) grant 5R01 ES023861 to the Carolina Population Center.

Acronyms

AE	Adult equivalent
ATT	Average treatment effect on the treated
C	Comparison group
CPC	Carolina Population Center
CPI	Consumer Price Index
DD	Difference-in-differences
GDP	Gross Domestic Product
IPW	Inverse Probability Weighting
ITT	Intent-to-treat
PC	Per capita
PMT	Proxy means test
PP	Percentage point
PSM	Propensity score matching
T	Treatment group
UNC	University of North Carolina at Chapel Hill
UNICEF	The United Nations Children's Fund
USD	United States dollar

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1. Introduction and background

1.1 Introduction

This document describes the study design and sample characteristics for the impact evaluation of Inyenyeri – a Rwandan social Benefit Company marketing a clean cooking solution that consists of the cleanest biomass burning improved cookstove on the market combined with sustainably produced biomass fuel pellets. The impact evaluation is implemented by the University of North Carolina at Chapel Hill (UNC) with technical and field support from Access Project (Baseline) and Laterite (Wave 2 and onward). This report describes the characteristics of households prior to their entrance into the program, and thus serves as an important basis for comparison of changes over time that allows for measurement of program impacts. The report also assesses the success of the study design, which entails random assignment of households into treatment and delayed-entry control groups. Specifically, the report tests whether the treatment and delayed-entry control groups are balanced across a range of key outcomes and impact indicators (environmental exposure to harmful pollutants, health and social welfare).

1.2 The Inyenyeri Clean Cooking Model

The Inyenyeri model couples the sale of sustainably produced biomass pellets with a complementary (cost-free) lease of the cleanest biomass burning improved cookstove on the market. Customers sign a contract to purchase biomass pellets, while receiving stoves to use free of cost for as long as the contract lasts. Pellets are produced in a pelletizing factory on the shores of Lake Kivu from sustainably sourced biomass feedstock (e.g., small eucalyptus trees and branches, elephant grass, sawdust etc.). Customers have the option of signing up for 30 kgs, 45 kgs, or 60 kgs per month, with the recommended quantity dependent on the size of the household. The company has decided to focus on marketing the fuel because fan gasifying stoves are too expensive to sell outright; by pricing biomass fuel pellets competitively relative to charcoal, households can adopt cleaner fuels and technologies at roughly the same cost as their baseline household energy system. Depending on the fuel pellet package that they purchase, households will receive one (30 kgs), two (45 kgs), or three (60 kgs) stoves. Inyenyeri currently uses a fan gasifying improved cookstove called the Mimi Moto. The Mimi Moto has been evaluated in a laboratory setting as a Tier 4 stove (GACC 2015), making it the cleanest burning biomass cookstove available on the market. As part of their business model Inyenyeri offers free delivery, training, repairs, and replacement of stoves.

1.3 Study objectives

The Inyenyeri impact evaluation is led and executed by UNC in collaboration with Access Project (Baseline) and Laterite (Wave 2 and onward). The impact evaluation consists of a baseline survey, two surveys, and an endline survey. The first midline survey is funded by the Global Alliance for Clean Cookstoves (GACC). The baseline, endline and all other midline surveys are funded by the National Institute of Environmental Health Sciences (NIEHS - R01 ES023861).

The objective of Inyenyeri is to transform household energy systems by providing a market-based mechanism for access to clean energy. Household air pollution (HAP) and ambient particulate matter (PM) are two of the world's most important contributors to the global disease burden. These two sources together accounted for approximately 6.7 million deaths and 7.6% of the loss of disability adjusted life years (DALY) in 2010 (Lim et al. 2013). In sub-Saharan Africa, HAP from solid fuels is the sixth highest

contributor to the burden of disease (Forouzanfar et al. 2015). Exposure to HAP and PM is primarily attributable to the burning of biomass fuels and the persistence of traditional cooking technologies. Despite the enormous health and welfare consequences of HAP, there are surprisingly few initiatives that present realistic opportunities for large-scale adoption of clean cooking technologies with the potential for reducing emissions to levels that will improve health. There is, thus, an urgent need to identify interventions that can lead to both the sustained use of biomass fuels and that can reach large numbers of households in developing countries.

There are four major research areas for evaluation: 1) personal exposure to HAP, 2) health outcomes for cooks and children in the household, 3) socioeconomic impacts on time use, labor allocation, and expenditures, 4) drivers and barriers to adoption of improved fuels and cookstoves. The objectives of the evaluation are to answer the following key questions on these topics:

1) Does adoption and sustained use of the Inyenyeri household energy system affect personal and cooking area exposure to carbon monoxide (CO), fine particulate matter ($PM_{2.5}$), and polycyclic aromatic hydrocarbons (PAH) for primary cooks?
2) Does adoption and sustained use of the Inyenyeri household energy system affect prevalence and type of morbidity of acute and chronic respiratory disease, cardiopulmonary disease, burns and eye irritation?
3) Does adoption and sustained use of the Inyenyeri household energy system affect time use and household well-being?
4) What factors affect adoption of the Inyenyeri household energy system?

1.4 Study area

Inyenyeri is located in Gisenyi, Rubavu District (Figure 1.4.1) in north-western Rwanda. Rwanda was selected by Inyenyeri due to the pressing need for clean cookstoves and more efficient biomass fuels, and also due to the relative ease of doing business. Rwanda provides one of the most population dense and biomass deficient settings in sub-Saharan Africa. Virtually all households in Rwanda cook their meals by burning fuel – wood, agricultural residues, or charcoal – in simple open flame stoves made of three stones, ceramics, or scrap metal. Urban households primarily cook with costly charcoal while rural households primarily cook with raw organic matter that they can collect for free, such as fuel wood and agricultural residues (Ndegwa, Breuer and Hamhaber 2011). Together, biomass and charcoal account for

Figure 1.4.1: Map of Rwanda showing location of Gisenyi

99% of all Rwandan cooking energy. Current forms of fuel use contribute to a myriad of environmental, social, and health problems, which all are exacerbated by Rwanda's high population growth rate (2.56%) and rate of urbanization (~6.43%) (CIA World Factbook 2016).

Gisenyi was specifically chosen as the launch site within Rwanda because of its existing ties to government officials, 30% lower overhead than the capital city of Kigali, proximity to poor rural households and proximity to the dense urban city of Goma, Democratic Republic of Congo (just 1 km from Inyenyeri's pilot pellet production factory). There is a great need for improved cooking technology in the DRC, but the relative unrest of the country prevents many organizations from establishing there. By basing operations in Gisenyi, Inyenyeri hopes to impact the DRC from the relative safety of Rwanda. Rwanda's central location in East Africa is also ideal for Inyenyeri's plans for scaling throughout the region.

1.5 Ethics reviews and approvals

The study was approved by the UNC Institutional Review Board (IRB). We also obtained approval from the Rwanda National Ethics Committee (RNEC). Study numbers are 14-0735 (UNC) and No. 348/RNEC/2015 (RNEC).

1.6 Study timeline

The planning and design of the study began in mid-June 2014. The survey instruments were finalized in May 2015 and training for the Heath, Poverty and Cooking (HPC) survey and exposure monitoring (EM) was conducted in Gisenyi in June 2015, and HPC and EM survey instruments and protocols were piloted at the end of the training. Field work began on 29 June 2015 and was completed on September 2nd, 2015. Table 1.6.1 describes the study timetable.

Table 1.6.1: Key Events for Rwanda HPC/EM Study

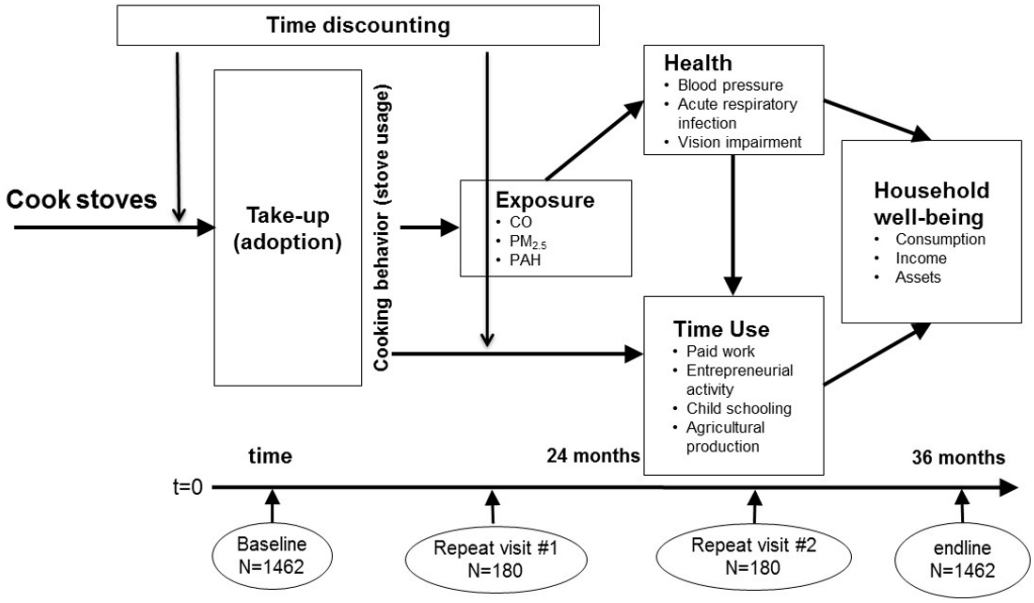
Event	Stakeholders	Timeframe
Identification of local partner	UNC, Access Project	July 2014
Pre-study reconnaissance	UNC, Inyenyeri	October/November 2014
Instruments designed, reviewed, approved	UNC	February-June 2015
Ethics reviews completed (UNC and Rwanda IRBs)	UNC, RNEC	May-June 2015
Enumerator training	UNC, Access Project	June 2015
Random household selection and assignment to treatment	UNC, Access Project	June 2015
HPC and EM instruments and protocols piloted and finalized	UNC, Access Project	June 2015
Data collection	UNC, Access Project	June-September 2015
Data analysis	UNC	November 2015 -August 2016
Sub-sample EM follow-up 1	UNC, Laterite	May-June 2016
Sub-sample EM follow-up 2	UNC, Laterite	June-July 2017
Endline Data collection	UNC, Laterite	Jan-April 2019

2. Conceptual Framework

This study brings together concepts from public health, environmental sciences and development economics to build an interdisciplinary theory of change for the evaluation of this intervention. Reductions in exposure to pollutants due to the clean cookstoves and fuel pellets, which is the direct or first level of potential impact we seek to measure, will depend on the specific household response to the intervention: how frequently it uses the stove(s) and pellets relative to traditional cooking energy systems. Reduction in exposure will in turn lead to health changes, as a longer-term impact. We also expect that changes in time-use patterns due to cookstove use will directly impact labor supply and livelihoods strategies, as households spend less time gathering or buying fuel, and cooking. Improved health will simultaneously indirectly affect labor productivity, and collectively we expect these various drivers of improved time use to ultimately impact household economic security and wealth. Figure 2.1.1 provides a visual depiction of the causal pathway that we envision; the figure is read from left to right, and the timeline at the bottom indicates our proposed data collection plan.

Adoption of improved fuels and cookstoves can be viewed as an inter-temporal decision because it often entails a trade-off between current expenditures (monetary cost of stove purchase, psychological and time costs associated with altering traditional and known routines) and longer-term benefits (chronic diseases, morbidity and mortality, climate and the environment). Consequently, behavioral parameters such as time discounting and the propensity to delay gratification may explain adoption and utilization patterns, much as they do for smoking (Baker et al. 2003), conservation (Hotelling 1931; Holden et al. 1998), and financial decisions (Frederick et al. 2002). In Figure 1, time discounting is shown as a potential moderator that helps explain utilization and subsequent economic decisions that entail inter-temporal trade-offs (leisure *vs.* work).

Figure 2.1.1: Effect of fuel pellets and clean cook stove adoption on health and wealth



3. Study Design and Sampling

3.1 Study Design

The overarching study design for the impact evaluation of Inyenyeri's household energy system is a household-level randomized encouragement design with multiple rounds of data collection implemented over the course of three years. The study takes place in 22 purposively selected *Umudugudus* in Gisenyi, Rubavu District. The baseline study was conducted between June-September 2015. Two rounds of follow-up survey will be collected at 12- and 24-months, and an endline survey will take place approximately 36 months after baseline data collection.

Data collected at baseline allows the study team to precisely describe characteristics of treatment households prior to receiving the intervention. The comparison will then be made with data collected in subsequent rounds, using a difference-in-differences (DD) approach to assess the full impacts of Inyenyeri's household energy system. The resulting difference from subtracting the outcomes of the control households pre- and post-intervention from those of the treatment households, also pre- and post-intervention in this DD approach is the impact directly linked to Inyenyeri's household energy system.

3.2 Sampling

3.2.1 Selection of Umudugudus

The sampling frame for the study comprised the list of the population of households (N=2,418) in Gisenyi sector provided by the Rubavu District Monitoring and Evaluation Officer. The study population area comprised all of Inyenyeri's existing urban and potential new urban markets that are in close proximity to

Inyenyeri's two main retail locations. Information for only the household head was selected and used for random sampling in the pre-determined study population of 22 villages or Umudugudus falling within Bugoyi and Kivumu Cells of Gisenyi town.

3.2.2 Selection of Households

Removing (a) households that were existing customers of Inyenyeri and (b) duplicates for household head's national ID number, the final sampling frame comprised 2,334 households. Using Microsoft Excel 2013, a random number was assigned to each household head in a meeting held with 22 village chiefs, 2 cell leaders and 1 sector leader on June 19, 2015. The random number variable was used to order household heads chronologically from the smallest to the largest random number (this variable is henceforth referred to as 'Order'), and the first 1,500 households were selected as the study population. The remaining households in the final sampling frame were retained as replacement households in their respective order.

3.2.3 Treatment and Control Assignment

Randomization protocol

After tossing a coin, the bottom 2/3rd of the 1500 selected households were assigned to the intervention group (treatment) and the top 1/3rd assigned to the delayed-entry control group. Replacements were drawn from the same village in order to maintain the original geographic representation of the sample. The intervention group received a house visit from Inyenyeri staff to explain the benefits of the stove and to go over the pricing options. This is the 'encouragement'.

Exclusion Criteria: A household was not surveyed if (a) the main respondent and/or the primary cook refused to participate; (b) the primary cook was less than 15 years old; (c) no cooking was done in the household; (d) the household was currently using or had previously used an improved stove such as the Philips gasifying stove (households were shown a flash card with pictures of the Del Agua/Eco Zoom Dura Stove and Philips Gasifying Stove as examples of improved stoves); (e) a sampled household was in the same plot as another that has already been surveyed; and (f) the village chief, key people in the village (such as community health worker) or neighbors had no information about the household sampled. If there was a new household residing in the same plot as the sampled household, and the original inhabitants listed in the sampling frame had moved to a different location, the survey was conducted with the new household.

Replacements protocol

Replacements: Each field supervisor received a list of sampled households, and a list of replacement households. If there was a need for replacement, the first household on the replacement list replaced the first household that needed to be replaced in the sampled households' list. Households on the replacement list would sequentially replace subsequent households to be replaced. Upon replacement, the enumerators recorded the household ID of the new/replacement household and the replacement household was assigned to the same treatment status as the household it replaced. Note that assignment status was known only to the study team and not enumerators or other field personnel

New Replacements: If the replacement list was exhausted, and the target number of households was not met, we selected households from among the list of households that were previously omitted owing to sharing a plot with another household that had already been interviewed. Following this strategy, all households in the same plot would receive the same intervention status. This complicated the replacement procedure because the replacement of a control group household required a replacement household that

shared a plot with another control household. This meant that the random order for replacement households could not be completely respected, due to the requirement that treatment and control households could not share the same plot due to spillover or contamination effects. Given that the village lists were incomplete and not updated to reflect the population in the study area during the time of the survey, it was challenging to obtain the target number of households for the study. Table 3.2.1 shows the breakdown of households by village and study arm. Ultimately, we were able to reach 95 percent of the target for a total baseline sample size of 1,462.

Table 3.2.1: Targeted and Surveyed Sample Size for HPC Baseline Survey

Visit Order	Village Name	Cell	Target Number of Households	Surveyed Number of Households	Treatment Households Surveyed	Control Households Surveyed
1	Muduha	Kivumu	44	44	32	12
2	Urumuri	Kivumu	51	52	40	12
3	Ubutabazi	Kivumu	96	96	66	30
4	Giponda	Kivumu	79	80	62	18
5	Bugoyi	Bugoyi	93	80	50	30
6	Itangazamakuru	Kivumu	84	84	50	34
7	Umurava	Kivumu	47	47	36	11
8	Isangano	Bugoyi	91	74	33	41
9	Igisubizo	Kivumu	51	51	30	21
10	Ubwiza	Bugoyi	47	47	27	20
11	Murisanga	Kivumu	49	40	24	16
12	Karisimbi	Kivumu	36	36	25	11
13	Ituze	Bugoyi	91	91	65	26
14	Ubukeraurugendo	Kivumu	51	52	34	18
15	Kivumu	Kivumu	104	105	68	37
16	Ubutabera	Bugoyi	59	59	43	16
17	Kaminuza	Bugoyi	55	55	37	18
18	Ubumwe	Kivumu	98	99	66	33
19	Giraneza	Bugoyi	101	98	72	26
20	Nyakabungo	Bugoyi	57	57	29	28
21	Irakiza	Bugoyi	45	44	26	18
22	Amataba	Bugoyi	71	71	48	23
Total number of households			1,500	1,462	963	499

3.2.4 Selection of Households for Sub-sample

Randomization protocol

Participating households were recruited from the larger sample of 1,462 households by the exposure monitoring (EM) team (four enumerators and one supervisor) after their contact information was given to the EM supervisor from the HPC team supervisor. Table 3.2 shows in detail the distribution of households for the exposure monitoring in each village surveyed.

All villages were stratified into small (<55 households), large (55-95 households) and very large (>95 households). For personal exposure monitoring, for (a) small villages, we selected the first 2 households on control households list and first 5 on the treatment households list; (b) large villages: first 3 households on the control households list and first 6 households on the treatment households list; and (c) very large villages: first 4 households on the control households list and first 6 households on the treatment

households list. For area monitoring (in treatment households only), in small and large villages, every other treatment household was selected; for very large villages, the first 2 treatment households were selected, followed by every other household. The total required sample of 60 control and 120 treatment (with 60 receiving area + personal exposure monitoring) was thus met. Comprehensive exposure monitoring was conducted in these 180 households at baseline

Stove use monitoring was accomplished by recording the temperature near stoves for four weeks with LabJack Digit-TL temperature data loggers. Stove use frequency and duration was inferred from the recorded temperature transients by the SUMSARIZER software (UC Berkeley). Monitoring was conducted on the two most commonly used stoves in each of the 180 EM households and select HPC households. Table 3.2.2 shows the target number and completed number of HPC households by village.

Table 3.2.2: Targeted and Surveyed Sample Size for EM Baseline Survey

Village Name	Target Number of Households	Surveyed Number of Households	Number of Replacement Households	Number of Refusals	Target number of HPC SUMs to add	SE SUMs completed
Muduha	8	8	1	0	3	2
Urumuri	8	8	0	0	3	1
Ubutabazi	10	10	3	1	9	13
Giponda	9	9	2	2	9	8
Bugoyi	9	9	3	1	9	8
Itangazamakuru	9	9	2	1	9	3
Umurava	7	7	0	0	5	3
Isangano	9	9	2	0	5	3
Igisubizo	7	7	0	2	5	5
Ubwiza	7	7	0	0	5	0
Murisanga	7	7	0	2	5	0
Kivumu	10	10	2	2	9	4
Karisimbi	7	7	1	1	5	5
Ituze	9	9	1	0	8	6
Ubukeraurugendo	7	7	1	0	5	3
Ubutabera	7	7	1	0	5	0
Kaminuza	7	7	0	0	5	0
Ubumwe	10	10	2	0	9	0
Giraneza	10	10	-[1]	-	9	0
Nyakabungo	7	7	-	-	5	0
Irakiza	7	7	-	-	5	0
Amataba	9	9	-	-	8	0
Column subtotal	*180*	*180*	*21*	*12*	*140*	*64*
1-22. subtotal / total		**180/ 180**	**21/ 180**	**12/180**		**64/140**
(%)		***100%***	***11.60%***	***6.60%***		***45.70%***

Note: [1] cells with "-" represent sample data lost due to unrecoverable computer encryption for laptop CPC15-303

Replacements protocol

A replacement strategy similar to that of the Health, Poverty and Cooking (HPC) survey was followed. The lead EM supervisor was given a list of replacement households by village, from among the 1,320 study households that were not originally sampled for EM data collection. The first household on the replacement list replaced the first household that needed to be replaced in the sampled households' list.

Households on the replacement list sequentially replaced subsequent households that needed to be replaced.

4. Survey Instruments and Data Collection

The baseline data collection consisted of three major components:

1. Household, Poverty and Cooking (HPC) Survey
    a. Household survey administered to the main respondent for the household
    b. Primary cook survey administered to the person who has done the majority of cooking in the household during the past 30 days
2. Exposure Monitoring (EM)
    a. Carbon monoxide (CO) monitoring of primary cook in the household for a 24 hours period
    b. Personal and area exposure monitoring of CO, PM2.5 and PAHs
3. Stove use monitoring (SUMS)

The exposure monitoring (EM) component of the study will evaluate the exposure to three indoor air pollutants (CO, fine particulate matter ≤2.5 μm ($PM_{2.5}$), and polycyclic aromatic hydrocarbons (PAHs)) produced by cooking practices. Personal breathing-zone exposure and on-site emission measurements were carried out in order to directly quantify the level of toxins that are emitted from the cookstoves and breathed in by the cooks, as well as to investigate the impact of the exposure on their health.

4.1 Training

Training of supervisors and enumerators was conducted over nine days from June 15-25, 2015 at La Corniche Hotel in Gisenyi. EM-team members attended an initial orientation session with the larger group of HPC enumerators, and then began specialized training for exposure monitoring.

4.1.1 HPC Training

The enumerators and supervisors were trained on the overall purpose of the project, research ethics, confidentiality and their behavioral conduct, such as not to promise any benefits to respondents either now or in the future. They were trained on basic definitions of household, household member, respondents and eligible member, and the exclusion criteria to be used prior to interviewing the household. A key complexity of the survey is that it includes special modules on attitudes towards and knowledge about cooking, preferences, and time-use for both the main decision-maker in the household and the main cook. This requires identifying, from the household roster, the identity of the main cook. In over one-third of the households, the main cook turned out to be an employee that often did not live in the household and so was not a household member. The survey also included a series of hypothetical questions to measure time- and risk-preference which required special attention during training. Considerable time was also spent on the detailed household expenditure module, which was based on the Rwanda national ECV and included over 120 individual expenditure items and enumerators and supervisors were trained in providing respondents with examples of items that they should consider in accounting for expenditures on all food and non-food items.

All the enumerators and supervisors were trained on how to appropriately (a) take anthropometric measurements of height and weight, and (b) make primary cooks wear the CO monitors. They were also explained that the primary cook should have been resting for at least 20 minutes prior to taking his/her blood pressure measurements.

The questionnaire was pilot tested among 20 households, and feedback from the pilot surveys were incorporated into the final survey instrument.

4.1.2 Exposure Monitoring and SUMS Training

Topics covered included equipment set-up and deployment, data collection, and data quality assurance analysis using CO monitors, $PM_{2.5}$-filter cartridges, PUF tubes, and Labjack stove-use monitors (SUMs). See the EM Manual (Appendix X) for a full description of training topics. After each topic was covered, each pair of EM enumerators practiced setting up all equipment while simultaneously filling out the questionnaire with responses from training staff, and model kitchen specifications.

4.2 Data Collection

4.2.1 Household, Poverty and Cooking Survey

The HPC questionnaire has 17 modules (all survey instruments are available at https://fuel.cpc.unc.edu/inyenyeri-rwanda/) and is approximately of two and a half hours duration depending on household size. Field teams consisted of one supervisor and four enumerators and enumerators were expected to complete two surveys per day. Prior to starting the interview, the enumerator would explain the purpose of the survey to the household member and then seek the consent of the main respondent and primary cook (informed consent of young adults 18-19 years, or assent of children 15-17 years). Primary cooks were also asked if they would be willing to allow the research team's colleagues to measure their air pollution exposure (from smoke produced from cooking and heating) for 24 hours, in the following days. They were also informed that though the device was not harmful in any way, it could cause some minor discomfort. All data was collected as is described in the Household Questionnaire Enumerator Manual which is also available at https://fuel.cpc.unc.edu/inyenyeri-rwanda/.

4.2.2 Exposure Monitoring

The EM questionnaire was divided into two main sections: (1) initial equipment set-up and (2) equipment pick-up after 24 hours. The first section included descriptions of equipment and the set-up, such as the pump flow-rates measured prior to deployment and the sample ID numbers. This section also included a description and the dimensions of the cooking area, questions for the cook about daily cooking practices, as well as a quantitative and qualitative description of the stoves and fuel used for cooking. The second section included many of the same questions, including the measured pump flow-rates post-deployment, a re-check of all sample IDs, a quantitative description of the remaining fuel and fuel type in the household, and a description of all cooking activities over the past 24 hours.

In each household, measurements of the primary cook's exposure to CO, $PM_{2.5}$, and PAHs were carried out over a period of 24 hours. Monitoring of CO, $PM_{2.5}$, and PAHs in the source area were measured simultaneously.

Two members of the EM team visited each household to explain the study and obtain consent from the primary cook. The enumerators then set up all monitoring equipment and gathered information about cooking practices and settings as directed by the EM questionnaire. The same enumerators returned after 24 hours to collect the equipment and to ask the post-monitoring survey questions from the primary cook. The same households will be approached in 12 months for the second round of sampling.

All equipment was calibrated at UNC prior to shipping to Gisenyi. Daily calibration of air-flow through each monitoring set-up was done prior to field deployment, using a BIOS Defender flowmeter

(MesaLabs, USA). Several filters were left untouched in the field office to be used as field blanks. See Appendix for a full description of calibration techniques.

The personal exposure-monitoring equipment (CO data logger EL-USB-CO300, Lascar Electronics); $PEM_{2.5}$ sampler (SKC Inc., Eighty Four, Pennsylvania, USA); PUF/XAD2 sampler (SKC Inc.) was incorporated into a small backpack that the cook wore continuously for 24 hours, with the exception of bathing and sleeping times. The area monitoring equipment was incorporated into a tripod (1-meter tall), which was placed one meter from the main cookstove for 24 hours. The heating and use of stoves was also measured, using electronic data loggers (SUMS, UC-Berkeley, California, USA). Each SUM was deployed for three weeks, starting with the day in which the 24-hour measurements of CO, $PM_{2.5}$, and PAHs were taken. The SUMs were attached to, or placed as close as possible, to the two main cookstoves in each house. All data was collected as is described in the Appendix (Exposure Monitoring Enumerator Guide).

The cross walk of the data to be collected at each wave and sample is shown in Table 4.2.1.

Table 4.2.1: Cross walk of measurements by wave and sample

	Full sample baseline	180 baseline	180 1st follow-up	180 2nd follow-up	Full sample endline	180 endline
Full HPC survey	X	X			X	X
Primary cook survey	X	X	X	X	X	X
Health survey	X	X	X	X	X	X
Stove use monitors	N=114	X	X	X		X
Area Monitoring						
CO		N=60				
$PM_{2.5}$		N=60				
PAH		N=60				
Cook Personal Monitoring						
CO	X	X	X	X		X
$PM_{2.5}$		X	X	X		X
PAH		X	X	X		X

4.3 Data Entry

4.3.1 Household, Poverty and Cooking Survey

Staff from the Carolina Population Center (CPC) trained the data manager and eight training participants from July 23-25, 2015 at The Access Project office in Kigali. Six data entry (DE) personnel were selected and two others were available to participate in DE as stand-ins, whenever required. Data entry was completed between July 27 and September 17, 2015. The data entry protocol involved three important steps that enabled maximum accuracy. First, the data entry program (CSPro) included considerable consistency checks to better data quality. Second, DE personnel would send data entry inconsistencies to the survey field team for verification and necessary correction. Third, every HPC survey was entered by two different DE personnel, allowing the CSPro in-built double data entry system to compare the two entries and determine irregularities which would then be discussed and resolved among the data entry staff and manager.

4.3.2 Exposure Monitoring

All data from the paper EM questionnaires filled out in the field were transferred to the Open Data Kit (ODK) database by the EM enumerators using six tablets in the field office.

The collected $PM_{2.5}$ and PAH samples were stored at the field office in Gisenyi before shipment to UNC for analysis. Once at UNC, samples were stored at –20°C prior to analysis. PAHs collected with the PUF-XAD2 tubes will be analyzed using gas chromatography-mass spectrometry (GC-MS) analysis. Filters used to collect $PM_{2.5}$ will be weighed to determine the mass of the particulate matter with aerodynamic diameter <2.5 µm. All data will be statistically analyzed to investigate the levels of airborne contaminants and adverse health effects caused by cooking practices in the 180 households selected for the study. In addition, CO monitoring data analysis will include both the 180 EM households and the 1500 households from the larger sample.

5. Description of study households

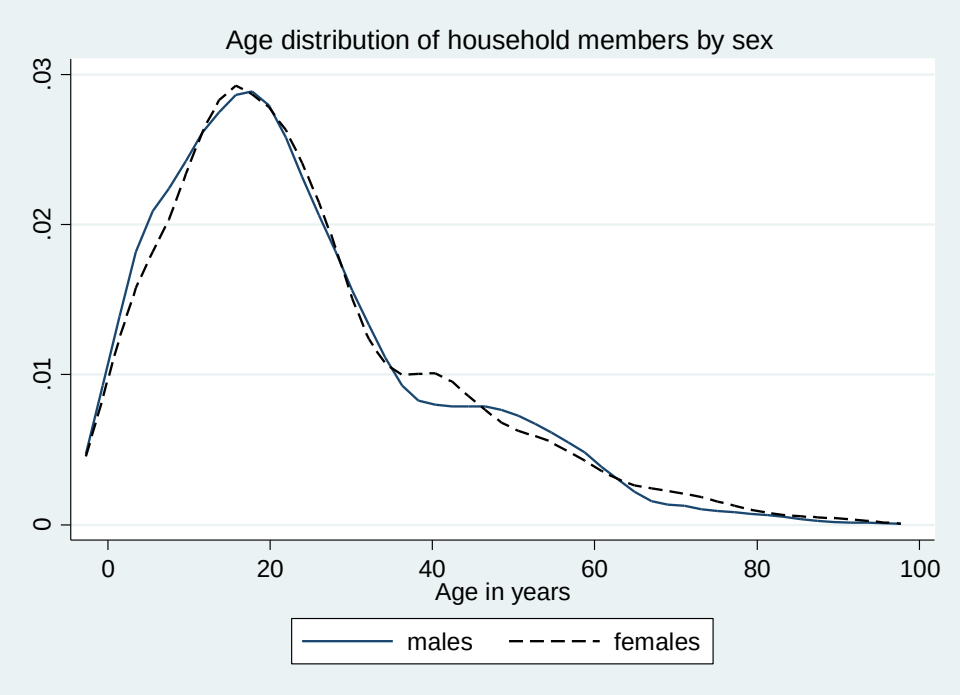
5.1 Demographics

This section presents the background characteristics of study households, main respondents, and primary cooks. As seen in Table 5.1.1, none of the main indicators show statistically significant differences between treatment and control groups at baseline. Table 5.1.2 displays the same indicators for the exposure monitoring (EM) sub-sample, again showing almost no significant differences between treatment and control. The details are found below.

5.1.1 Age Distribution by Sex

The mean age of household members is 24 and is the same for males and females. The distribution of the age of household members by sex is depicted in Figure 5.1.1. While mean age is the same, there are slightly fewer female children and slightly more females around age 40 and between 65 and 80 years.

Figure 5.1.1: Age distribution of household members by sex



5.1.2 Current Marital Status

Sixty percent of household members are not married, 33% are married or living together, 5.4% are widowed and a smaller percentage (2.1%) of household members are separated or divorced. There are no significant differences between the treatment and control groups in the full sample or the sub-sample of 180 households.

5.1.3 Current School Enrolment

Among children in the school-going age group of 5-17 years, 52.3% are not attending school, 40.2% are day students and 7.5% are day boarders.

Table 5.1.1: Demographic Indicators: Balance between Treatment and Control Groups at Baseline, Full sample

	Full Sample			Treatment			Control			Diff T-C	p-value
	%	SD	N	% (T)	SD (T)	N (T)	% (C)	SD (C)	N (C)		
Household Characteristics											
Total Household Members (mean)	5.3	2.7	1462	5.2	2.7	963	5.3	2.8	499	0.72	0.47
Children (0-5 years) (mean)	0.6	0.8	1462	0.5	0.8	963	0.6	0.8	499	1.18	0.24
Children (6-12 years) (mean)	0.9	1.1	1462	0.9	1.1	963	0.8	1.1	499	-0.36	0.72
Children (13-17 years) (mean)	0.8	1.0	1462	0.7	1.0	963	0.8	1.1	499	1.08	0.28
Adults (18-24 years) (mean)	1.0	1.2	1462	1.0	1.1	963	1.0	1.2	499	-0.61	0.54
Adults (25-34 years) (mean)	0.8	0.9	1462	0.8	0.9	963	0.9	0.9	499	0.36	0.72
Adults (35-44 years) (mean)	0.5	0.7	1462	0.5	0.6	963	0.5	0.7	499	0.54	0.59
Adults (45-54 years) (mean)	0.4	0.6	1462	0.4	0.6	963	0.4	0.6	499	0.91	0.36
Adults (55-64 years) (mean)	0.2	0.5	1462	0.2	0.5	963	0.2	0.5	499	-0.87	0.39
Elderly (>64 years) (mean)	0.2	0.5	1462	0.2	0.5	963	0.2	0.5	499	0.43	0.67
Current Marital Status (12 and older)											
Never married	60.0		1462	60.2		963	59.6		499	0.45	0.65
Married/cohabitating	32.5		1462	32.2		963	33.0		499	-0.60	0.55
Separated/divorced	2.1		1462	2.1		963	2.1		499	0.07	0.95
Widowed	5.4		1462	5.5		963	5.3		499	0.39	0.70
Current School Enrollment (5-17 years)						963			499		
Not attending school	52.3		1462	52.0		963	53.1		499	-0.85	0.39
Day Student	40.2		1462	40.3		963	40.0		499	0.23	0.82
Day Boarder	7.5		1462	7.8		963	6.9		499	0.94	0.35

Table 5.1.1: Demographic Indicators: Balance between Treatment and Control Groups at Baseline, Full sample (continued)

	Full Sample			Treatment			Control			Diff T-C	p-value
	%	SD	N	% (T)	SD (T)	N (T)	% (C)	SD (C)	N (C)		
Main Respondent's Characteristics											
Age (mean)	38.5	14.4	1462	38.3	14.3	963	38.7	14.7	499	0.49	0.63
Female	80.3		1462	80.4		963	80.2		499	0.10	0.92
Current Marital Status											
Never married	25.1		1462	24.5		963	26.3		499	-0.72	0.47
Married/cohabitating	56.7		1462	56.4		963	57.3		499	-0.34	0.73
Separated/divorced	5.6		1462	5.8		963	5.2		499	0.48	0.63
Widowed	12.6		1462	13.3		963	11.2		499	1.16	0.25
Literacy	91.1		1462	90.8		963	91.8		499	0.66	0.51
Education											
None	8.7		1462	9.5		963	7.2		499	1.50	0.14
Pre-Primary and Primary	21.2		1462	19.9		963	23.7		499	-1.61	0.11
TVET	1.1		1462	0.9		963	1.4		499	-0.77	0.44
Secondary	39.7		1462	39.5		963	40.1		499	-0.23	0.82
University	29.3		1462	30.2		963	27.7		499	1.03	0.30
Main Cook's Characteristics											
Age (mean)	30.8	14.0	1462	30.9	14.1	963	30.7	13.9	499	0.20	0.79
Female	77.6		1462	77.5		963	78.0		499	-0.01	0.83
Literacy	84.9		1462	84.3		963	85.8		499	-0.02	0.46
Education											
None	13.3		1462	14.3		963	11.4		499	0.03	0.11
Pre-Primary and Primary	38.7		1462	38.0		963	40.3		499	-0.02	0.40
TVET	0.8		1462	0.6		963	1.2		499	-0.01	0.29
Secondary	35.7		1462	36.0		963	34.9		499	0.01	0.66
University	11.4		1462	11.0		963	12.2		499	-0.01	0.49
Relationship to main respondent											
Self	53.0		1462	52.5		963	53.9		499	-0.01	0.62
Family member	12.5		1462	12.7		963	12.2		499	0.00	0.81
Domestic hire	34.5		1462	34.8		963	33.9		499	0.01	0.72

Table 5.1.2: Demographic Indicators: Balance between Treatment and Control Groups at Baseline, EM Sample

	EM Sample			Treatment			Control			Diff T-C	p-value
	%	SD	N	% (T)	SD (T)	N (T)	% (C)	SD (C)	N (C)		
Household Characteristics											
Total Household Members (mean)	5.3	2.5	180	5.4	2.5	122	5.6	2.6	58	0.39	0.70
Children (0-5 years) (mean)	0.6	0.8	180	0.6	0.8	122	0.7	0.8	58	0.57	0.57
Children (6-12 years) (mean)	0.9	1.1	180	0.9	1.1	122	0.9	1.0	58	-0.07	0.94
Children (13-17 years) (mean)	0.8	0.9	180	0.7	1.0	122	0.7	0.9	58	-0.56	0.58
Adults (18-24 years) (mean)	1.0	1.2	180	1.1	1.2	122	1.0	1.3	58	-0.20	0.84
Adults (25-34 years) (mean)	0.8	0.9	180	0.8	0.9	122	0.9	0.9	58	0.67	0.51
Adults (35-44 years) (mean)	0.5	0.7	180	0.5	0.7	122	0.6	0.7	58	0.47	0.64
Adults (45-54 years) (mean)	0.4	0.6	180	0.3	0.6	122	0.3	0.6	58	0.26	0.80
Adults (55-64 years) (mean)	0.2	0.5	180	0.2	0.5	122	0.3	0.5	58	0.47	0.64
Elderly (>64 years) (mean)	0.2	0.5	180	0.2	0.5	122	0.2	0.5	58	0.14	0.14
Current Marital Status (12 and older)											
Never married	60.0		180	58.7		122	59.8		58	-0.01	0.76
Married/cohabitating	32.5		180	35.2		122	33.9		58	0.01	0.75
Separated/divorced	2.1		180	1.4		122	1.3		58	0.00	0.85
Widowed	5.4		180	4.7		122	5.0		58	0.00	0.84
Current School Enrollment (5-17 years)											
Not attending school	52.3		180	54.0		122	52.5		58	0.02	0.69
Day Student	40.2		180	37.8		122	39.4		58	-0.02	0.64
Day Boarder	7.5		180	8.2		122	8.1		58	0.00	0.96

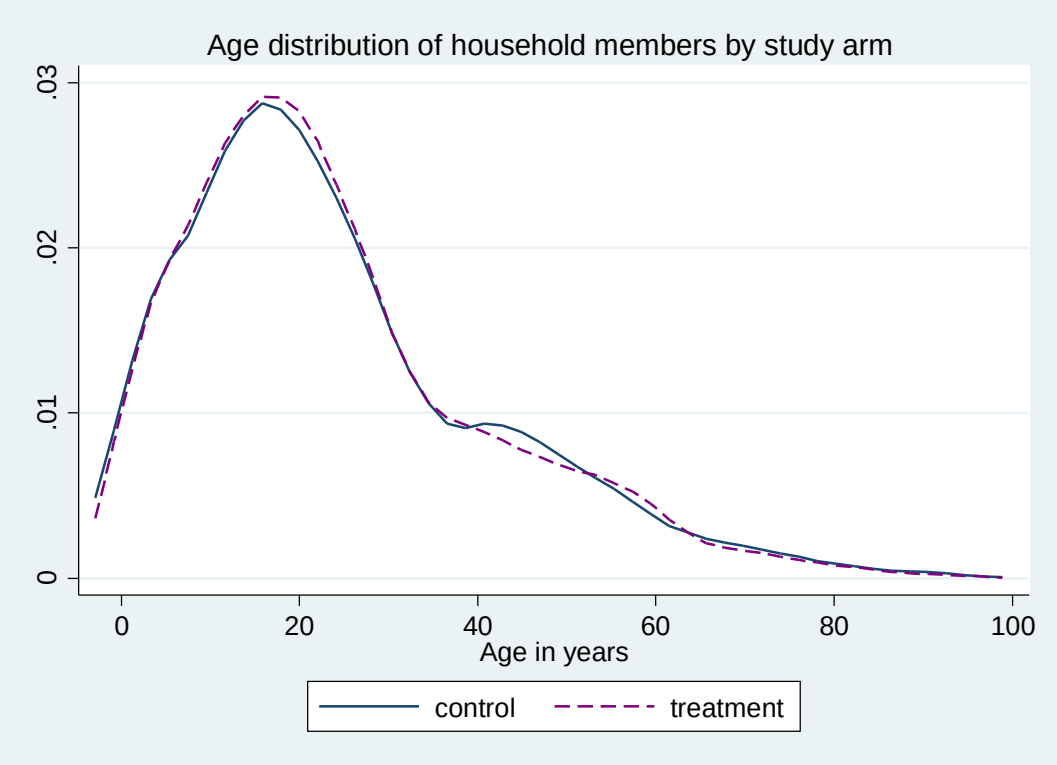
Table 5.1.2: Demographic Indicators: Balance between Treatment and Control Groups at Baseline, EM Sample

	EM Sample			Treatment			Control			Diff T-C	p-value
	%	SD	N	% (T)	SD (T)	N (T)	% (C)	SD (C)	N (C)		
Main Respondent's Characteristics											
Age (mean)	38.3	14.5	180	36.9	13.8	122	41.3	15.7	58	1.94	0.05
Female	82.7		180	84.4		122	79.3		58	0.05	0.42
Current Marital Status											
Never married	23.5		180	24.6		122	20.7		58	0.04	0.56
Married/cohabitating	60.9		180	60.7		122	62.1		58	-0.01	0.86
Separated/divorced	5.0		180	5.7		122	3.4		58	0.02	0.48
Widowed	10.6		180	9.0		122	13.8		58	-0.05	0.36
Literacy	94.4		180	93.4		122	96.6		58	-0.03	0.35
Education											
None	7.3		180	9.0		122	3.4		58	0.06	0.12
Pre-Primary and Primary	23.5		180	19.7		122	31.0		58	-0.11	0.11
TVET	1.1		180	0.8		122	1.7		58	-0.01	0.64
Secondary	39.7		180	42.6		122	34.5		58	0.08	0.29
University	28.5		180	27.9		122	29.3		58	-0.01	0.84
Main Cook's Characteristics											
Age (mean)	29.9	14.1	180	29.2	13.6	122	31.3	15.3	58	-2.01	0.39
Female	80.4		180	77.9		122	84.5		58	-0.07	0.28
Literacy	87.2		180	85.2		122	91.4		58	-0.06	0.21
Education											
None	9.5		180	9.8		122	8.6		58	0.01	0.79
Pre-Primary and Primary	45.3		180	43.4		122	50.0		58	-0.07	0.41
TVET	1.7		180	0.0		122	5.2		58	-0.05	0.08
Secondary	31.3		180	34.4		122	24.1		58	0.10	0.15
University	12.3		180	12.3		122	12.1		58	0.00	0.97
Relationship to main respondent											
Self	46.9		180	45.9		122	48.3		58	-0.02	0.77
Family member	13.4		180	14.8		122	10.3		58	0.04	0.39
Domestic hire	39.7		180	39.3		122	41.4		58	-0.02	0.80

5.1.3 Household Characteristics

On average, each household contains 5.3 household members. There is an average of one adult in the age groups 18-24 years, 25-34 years and 35-44 years, and one child in each of the 0-5 years, 6-12 years and 13-18 years age groups.. The mean number of adults in the age groups 45-54 years, 55-64 years and above 64 years is below 1 and the overall mean age of members is 24. There are no significant differences in the average number of household members across all age groups between the treatment and control groups in the full and sub-sample. Figure 5.1.3 depicts the age distribution of household members by study arm.

Figure 5.1.3: Age distribution of household members by study arm



5.1.4 Main Respondent Characteristics

The average age of the main respondent in the full sample is 38.5 years, and 80% of the respondents are female. More than half of the respondents (56.7%) are married or cohabiting, 25% are not married, 13% are widowed and 6% are separated or divorced. The high literacy rate – 91% of the respondents are literate, meaning they can read and write in either English, French or Kinyarwanda – mirrors the main respondents' highest level of education; approximately 40% of them have secondary education, 29% have completed university-level education, 21.2% have studied up to pre-primary and primary levels, and a smaller percentage of 8.7% have no formal education. There are no significant differences between the treatment and control groups on all these characteristics of main respondents, both in the full and sub-sample.

5.1.5 Primary Cook Characteristics

The primary cook sample (N=1462) partially intersects with the main respondent sample: more than half of the primary cooks in the full sample (53%) are the main respondent (N=775). However, there are also some important differences: 34.6% of the cooks are domestic hires (N=504) and 12.4% are family members (N=183). The majority – 78% -- of primary cooks are female, with a mean age of 30.8 years. The literacy rates are somewhat lower than those for the main respondents, with 85% of the primary cooks literate. Formal education rates are similarly lower: majority of the primary cooks have completed formal schooling up to pre-primary and primary levels (38.7%), followed by secondary level (35.7%), and 13% of them have not attended school. A small percentage of primary cooks (11.4%) have completed university-level formal education, compared to 29% of the main respondents. Similarly to the main respondents' characteristics, among primary cooks there were no statistically significant differences between treatment and control groups.

5.2 Dwelling

5.2.1 Status of Housing Occupancy

As seen in Table 5.2.1, the majority of the households are living in single houses (51.3%), followed by multiple houses (24.5%) and multiple groups of enclosed dwellings (18%). There is a significantly higher percentage of households in the control group (7.4%) living in a single group of enclosed dwellings, compared to those in the treatment group (4.7%) (p=0.04). On average, households occupy 4.2 rooms, and have been staying at their current dwelling for 7.8 years. Approximately half the households (49.1%) own the dwelling they are occupying, 40% are tenants but paid no rent, 6.4% own the dwelling but had taken a loan, and a smaller percentage of households are paid tenants (4.4%).

5.2.2 Physical Characteristics

Over half the dwellings are constructed with oven fired bricks (52.3%), 29.7% with mud bricks, 13.8% with cemented mud bricks and 4.2% with cement blocks. The vast majority of dwellings' roofs are made of grass (97.5%), and a very small percentage with metal sheets (1.3%). Eighty percent dwellings' floors are made of material other than cement, clay tiles and beaten earth.

Ninety-six percent households have access to electricity, and electricity is the main lighting source (95.5%). Over 90% households have access to piped drinking water either in their dwelling or yard/plot. A fewer percentage of households use public taps or standpipes (6.8%) and tubewell or borehole (2.3%) as their main drinking water source. Fifty-seven percent households use a flush latrine and 42.5% use a pit latrine. Majority of households throw garbage in their fields or bushes (82%), some compost heap on their own property (6.8%), some dispose of garbage in a publicly managed refuse area (6.4%) and a much smaller percentage of households burn the garbage (3.3%). Charcoal is the primary cooking fuel source (94%), followed by fuelwood (3%) and kerosene or paraffin (2.5%). There are no significant differences between treatment and control groups on either the status of housing occupancy or any of the physical characteristics.

The housing characteristics in the sub-sample of 180 households mirror the percentages in the full sample. None of the control group households have cemented floors, and this is significantly lower than the 4.9% treatment households with cemented floors (p=0.01) Other than this characteristic, there are no significant differences between treatment and control groups at the 95% significance level.

Table 5.2.1: Housing Indicators: Balance between Treatment and Control Groups at Baseline

	Full Sample			Treatment			Control			Diff T-C	p-value
	%	SD	N	%	SD (T)	N	%	SD (C)	N		
Dwelling type											
Group of enclosed dwellings-multiple	18.0		1462	17.7		963	18.6		499	-0.01	0.65
Group of enclosed dwellings-single	5.6		1462	4.7		963	7.4		499	-0.03	0.04
Single house	51.3		1462	51.8		963	50.3		499	0.02	0.58
Multiple house	24.5		1462	25.1		963	23.4		499	0.02	0.48
Other	0.5		1462	0.7		963	0.2		499	0.01	0.12
Number of rooms occupied by household (mean)	4.2	1.7	1462	4.2	1.6	963	4.3	1.8	499	-0.09	0.34
Duration of hh staying in dwelling (in years) (mean)	7.8	8.5	1462	7.7	8.8	963	7.9	8.1	499	-0.21	0.65
Occupancy type											
Owner occupier-no loan	49.1		1462	47.4		963	52.7		499	-0.05	0.05
Tenancy-rent paid	4.4		1462	4.7		963	3.8		499	0.01	0.43
Tenancy-no rent paid	40.0		1462	40.7		963	38.7		499	0.02	0.45
Owner occupier-with loan	6.4		1462	7.3		963	4.8		499	0.03	0.05
Dwelling exterior wall construction material											
Mud bricks with cement	13.8		1462	13.5		963	14.4		499	-0.01	0.63
Oven fired bricks	52.3		1462	53.2		963	50.5		499	0.03	0.33
Mud bricks	29.7		1462	29.2		963	30.9		499	-0.02	0.51
Cement blocks	4.2		1462	4.2		963	4.2		499	0.00	0.96
Dwelling roof material											
Metal sheets	1.3		1462	1.6		963	0.8		499	0.01	0.18
Grass	97.5		1462	97.0		963	98.4		499	-0.01	0.07
Clay tiles	0.8		1462	0.9		963	0.6		499	0.00	0.47
Other	0.4		1462	0.5		963	0.2		499	0.00	0.30
Dwelling floor material											
Cement	4.1		1462	4.4		963	3.6		499	0.01	0.48
Clay tiles	0.8		1462	0.8		963	0.8		499	0.00	0.95
Beaten earth	15.3		1462	14.8		963	16.2		499	-0.01	0.49
Other	79.8		1462	80.0		963	79.4		499	0.01	0.79
Main source of drinking water											
Piped to yard/plot	24.7		1462	25.6		963	23.0		499	0.03	0.27
Piped into dwelling	65.6		1462	64.2		963	68.1		499	-0.04	0.13
Public tap/standpipe	6.8		1462	7.4		963	5.8		499	0.02	0.25
Bottled water	0.5		1462	0.4		963	0.8		499	0.00	0.39
Tubewell/borehole/others	2.3		1462	2.4		963	2.2		499	0.00	0.82

Table 5.2.1: Housing Indicators: Balance between Treatment and Control Groups at Baseline (cont'd)

	Full Sample			Treatment			Control			Diff T-C	p-value
	%	SD	N	%	SD	N	%	SD	N		
Access to electricity	95.6		1462	95.5		963	95.8		499	0.00	0.82
Main lighting source											
Electricity	95.5		1462	95.5		963	95.4		499	0.00	0.90
Other (kerosene/paraffin, candle, solar, batteries/bulb)	4.5		1462	4.5		963	4.6		499	0.00	0.90
Main cooking fuel source											
Charcoal	94.0		1462	94.7		963	92.6		499	0.02	0.12
Fuelwood	3.0		1462	2.5		963	4.0		499	-0.02	0.13
Electricity/LPG	0.3		1462	0.1		963	0.6		499	-0.01	0.17
Reeds/straw	0.3		1462	0.3		963	0.2		499	0.00	0.68
Kerosene/paraffin	2.5		1462	2.4		963	2.6		499	0.00	0.80
Main toilet											
Pit latrine	42.5		1462	41.0		963	45.5		499	-0.05	0.10
Flush toilet	57.3		1462	58.7		963	54.5		499	0.04	0.13
No toilet	0.2		1462	0.3		963	0.0		499	0.00	
Garbage disposal method											
Rubbish collection service	1.4		1462	1.3		963	1.6		499	0.00	0.71
Household's fields/bushes	82.0		1462	81.7		963	82.6		499	-0.01	0.69
Compost on own property	6.8		1462	7.1		963	6.4		499	0.01	0.64
Burnt	3.3		1462	3.5		963	2.8		499	0.01	0.45
Publicly managed refuse area	6.4		1462	6.3		963	6.6		499	0.00	0.84

5.3 Cooking Characteristics

5.3.1 Type of Cooking Area

Most households have a structure outside of their primary dwelling where they cook (65.8%). Bricks of varying qualities are the most common construction material for kitchen walls (93.0%) (among the types of bricks, mud bricks fixed with cement was most common (52.3%)), metal sheets are the most common roofing material (96.9%), and most cooking areas outside of the primary dwelling have cement floors (64.7%).

5.3.2 Ventilation in Cooking Area

We consider ventilation to be an important determinant of exposure to household air pollution. As seen in Table 5.3.1, roughly 16% of study households do the majority of cooking in a kitchen inside the primary dwelling. Another 5.5% of households do most of their cooking in a bedroom or sitting room also located in the primary dwelling. For most households cooking takes place in a designated kitchen that is situated outside of the primary dwelling (56.3%). Cooking in a quasi-ventilated space was relatively common; households reported doing most of their cooking on the veranda (10.1%) or in a sheltered area outdoors (2.5%). Approximately 10% of households cook fully outdoors in an unsheltered setting, which we expect to have the best ventilation.

Table 5.3.1: Kitchen Structure Indicators

	Full Sample			Treatment			Control			Diff	p-
	%	SD	N	%	SD	N	%	SD	N	T-C	value
Kitchen structure outside dwelling	65.8		1462	65.9		963	65.5		499	0.00	0.88
Kitchen wall											
Mud bricks	17.3		962	18.6		635	14.7		327	0.04	0.12
Mud bricks with cement	52.3		962	51.8		635	53.5		327	-0.02	0.62
Oven fired bricks	23.4		962	23.3		635	23.5		327	0.00	0.93
Cement blocks and others	7		962	6.3		635	8.3		327	-0.02	0.28
Kitchen roof											
Metal sheets	96.6		962	96.1		635	97.6		327	-0.02	0.20
Clay tiles, grass and others	3.4		962	3.9		635	2.4		327	0.02	0.20
Kitchen floor											
Beaten earth	28.1		962	28.8		635	26.6		327	0.02	0.47
Clay tiles, bricks and others	7.2		962	6.3		635	8.9		327	-0.03	0.16
Cement	64.7		962	64.9		635	64.5		327	0.00	0.91
Cooking location											
Kitchen outside primary dwelling	56.3		1462	56.5		963	56.1		499	0.00	0.89
Kitchen inside primary dwelling	15.8		1462	16.2		963	15.0		499	0.01	0.56
Veranda	10.1		1462	9.8		963	10.6		499	-0.01	0.61
Outside (unsheltered)	9.7		1462	10.2		963	8.8		499	0.01	0.40
Outside (sheltered)	2.5		1462	2.7		963	2.2		499	0.01	0.56
Other room	5.5		1462	4.7		963	7.2		499	-0.03	0.06
Gap between walls and ceiling in cooking area	22.5		1462	21.9		745	23.5		391	-0.02	0.53
Number of windows in cooking area (mean)	0.6	0.6	1462	0.6	0.7	963	0.6	0.6	499	0.00	0.91
Ventilation holes in cooking area	40.7		1462	41.8		963	38.7		499	0.03	0.24
Soot line in cooking area	55.9		1462	56.1		963	55.7		499	0.00	0.90
Soot on the ceiling	54.5		1462	55.3		963	52.9		499	0.02	0.38
Active chimney to remove smoke	5.7		1462	4.9		963	7.4		499	-0.03	0.06
Pitch of cooking area											
None	23.1		1462	23.5		963	22.4		499	0.01	0.66
Deep inverted V	1.2		1462	1.5		963	0.8		499	0.01	0.24
Shallow inverted V	3.2		1462	3.4		963	2.8		499	0.01	0.51
Downward sloping towards door	46.7		1462	46.5		963	47.3		499	-0.01	0.78
Upward sloping towards door	7.7		1462	6.9		963	9.4		499	-0.03	0.10
Flat	17.9		1462	18.3		963	17.2		499	0.01	0.62

For households with designated indoor or quasi-indoor cooking areas (N=1320) we collected data for a number of variables that might influence ventilation and therefore exposure to HAP (Table 5.3.1). In our sample only 22.5% of households have a gap between the walls and the ceiling in their cooking area, and 5.7% have an active chimney designed to remove smoke from the cooking area. The average number of windows in the cooking area is 0.6, and 40% of households have ventilation holes (intentional holes or spacing between bricks that allow air to escape) in the cooking area. The majority of cooking areas have roofs that slope downward toward the door (46.7%); flat roofs are also relatively common (17.9%). Soot lines are evidence of HAP getting trapped in the cooking area, as they signal overall poor ventilation. We observed soot lines on walls in 55.9% of cooking areas, and on 54.5% of ceilings in cooking areas. Overall we have good balance between treatment and control on all characteristics of the cooking area. The only exception is within the EM sample for the variable indicating a gap between the walls and ceiling. Twenty-three percent of households in the EM treatment group have a gap, whereas 9.3% of households in the control group have a gap.

5.3.3 Cooking Technology and Fuel Use

Stove ownership in study households is dominated by relatively simple and locally made portable and fixed charcoal stoves. Most households at baseline have a portable or fixed charcoal stove (77.6% and 33.4% respectively). A higher proportion of households in the control group (37.9%) have fixed charcoal stoves than in the treatment group (31.2%). Improved stoves (e.g., those that use gas or electricity) are owned by 9.1% of households (6.2% gas; 2.9% electric). Traditional (e.g., three stone) or clay stoves that use fuelwood are the third most common category of stoves owned by study households (7.1% and 2.1% respectively). Only 0.3% of households at baseline own a forced draft gasifying stove. Apart from statistically significant differences in numbers of treatment and control households with fixed charcoal stoves, we have good balance across study arms. Stove use in the household during the past 30 days strongly mirrors stove ownership. Portable charcoal stoves are used by 75.2% of households, and fixed charcoal stoves are used by 30.1% of households. Modern fuel stoves and traditional/clay stoves are used by 7.6% and 7.9% of households respectively.

Table 5.3.2: Cooking Technology and Fuels Indicators

	Full Sample		**Treatment**		**Control**		**Mean**	**p-value**
	%	N	%	N	%	N		
Stove used in the past 30 days								
Traditional stove-past 30 days	6.1	1462	5.8	963	6.6	499	-0.01	0.55
Clay firewood stove-past 30 days	1.8	1462	1.3	963	2.8	499	-0.02	0.08
Portable charcoal stove-past 30 days	75.2	1462	76.1	963	73.3	499	0.03	0.25
Fixed charcoal stove-past 30 days	30.1	1462	27.9	963	34.5	499	-0.07	0.01
Forced gassifying stove-past 30 days	0.2	1462	0.1	963	0.4	499	0.00	0.33
Kerosene stove-past 30 days	0.5	1462	0.6	963	0.2	499	0.00	0.19
Gas cooker-past 30 days	5.3	1462	5.5	963	5.0	499	0.01	0.69
Electric cooker-past 30 days	2.3	1462	2.7	963	1.8	499	0.01	0.26
Other stove-past 30 days	0.3	1462	0.3	963	0.2	499	0.00	0.68

Table 5.3.2: Cooking Technology and Fuels Indicators (continued)

	Full Sample		Treatment		Control		Mean	p-value
	%	N	%	N	%	N		
Fuel used in the past 30 days								
Charcoal	97.5	1462	98.0	963	96.6	499	0.01	0.12
Fuelwood	9.9	1462	8.7	963	12.0	499	-0.03	0.06
Biomass pellets	0.1	1462	0.0	963	0.2	499	0.00	0.32
Kerosene	0.5	1462	0.6	963	0.2	499	0.00	0.19
Electricity	2.5	1462	3.0	963	1.8	499	0.01	0.14
LPG	5.3	1462	5.5	963	5.0	499	0.01	0.69
Biogas	0.1	1462	0.1	963	0.0	499	0.00	0.32

As seen in Table 5.3.2, households used charcoal stoves for majority of their cooking, with portable charcoal stove forming 67.1% of the share of cooking in the past 30 days, followed by fixed charcoal stove (25.5%). Approximately 3% cooking was done on traditional stoves and 2.5% cooking on gas cookers. There are no statistically significant differences between treatment and control group households on share of meals cooked with different stoves.

Following the pattern of share of meals cooked on stoves, on average, study households owned portable charcoal stoves for the longest duration (6.1 years), followed by fixed charcoal stoves (1.9 years) and traditional stoves (0.8 years).

Fuel use closely follows stove use (Table 5.3.2). Of **cooking fuels used in the household during the past 30 days**, charcoal was used by 97.5% of household in the sample. Fuelwood is used by 9.9% of households, and modern fuels are used by 8.8% of households (2.5% electricity; 5.3% liquid petroleum gas (LPG)).

Majority meals were cooked using charcoal (92%). Fuelwood (4.2%) and LPG (2.5%) formed a much smaller share of cooking fuel used in the past 30 days.

We also asked the main cook in the household what quantities of fuel were used in the household during the past 7 days. Charcoal is the dominant fuel, with households using an average of 14.7 kgs of charcoal per week. Fuelwood was the second most common fuel, households used an average of 1.5 kgs/week. Quantities of biomass pellets, paraffin, and LGP were negligible.

On average, households purchased LPG worth 19, 595 RWF, fuelwood worth 18, 414 RWF and charcoal worth 12,750 RWF in the 30 days prior to the survey. The mean value of LPG used but not purchased (e.g. gifted) is 19,060 RWF. Fuelwood and charcoal for cooking that were either collected or gifted are worth 9,129 RWF and 1,041 RWF, respectively. The chapter on Consumption provides more detail on fuel expenditure.

5.3.4 Perceptions of Cooking Practices—Main Respondent and Primary Cook

Perceptions about negative impacts of cooking practices

There are striking differences about awareness of negative health, environmental, and air quality impacts between main respondents (N=1,462) and primary cooks (N=687) in the household. When asked if they had ever heard about whether cooking practices negatively impact health and health of children 61.8% of main respondents said ‘yes’, compared with 45.6% of primary cooks. Patterns were similar for both awareness about cooking practices negatively impacting forests (63.7% vs. 49.4% for main respondent and primary cook respectively), and awareness about cooking practices negatively affecting air quality (65.4% vs. 48.8%). For those who had heard about the negative impacts of cooking, most received that information from the radio (e.g., 43.9% of main respondents heard about the negative health impacts of cooking practices on the radio). Other important information sources for main respondents were: school lessons/teachers; TV advertisements; and self-realization. Doctors and public health workers are only reaching a small share of main respondents in our sample with messages about the negative impacts of cooking practices. Approximately 4% of messaging about negative impacts was received from the public health community. Trends were similar for primary cooks who were aware of the negative impacts of cooking practices, however radio played a larger role in messaging, particularly on environmental and air quality outcomes (57.8% and 52.2% of primary cooks who were aware of negative impacts heard from the radio), and doctors and public health works played a smaller role.

What to do about negative impacts of cooking practices

When asked what actions can be taken to mitigate the negative health, environment and air quality impacts of cooking practices **main respondents** indicated that to reduce negative health impacts they could use cleaner burning fuels (26.7%), use cleaner stoves (25.6%), and keep children out of the kitchen (13.5%). To reduce negative impacts on forests main respondents indicated they should burn less firewood (28.0%), use cleaner burning fuels (25.1), and use cleaner stoves (17.2). Tree planting (16.3) was also mentioned as a mitigation strategy. To reduce air quality impacts main respondents suggested using cleaner burning fuels (35.0%), using cleaner stoves (23.4%), and burning less firewood (12.8%).

Table 5.3.3: Main respondents' and primary cooks' cooking perceptions

	Main respondent								Primary cook							
	Full Sample		Treatment		Control		Diff	p-value	Full Sample		Treatment		Control		Diff	p-value
	%	N	%	N	%	N	T-C		%	N	%	N	%	N	T-C	
Ever heard about cooking practices negatively impact your health and health of your children	61.8	1462	61.5	963	62.5	499	-0.01	0.70	58.1	775	56.5	506	61.0	269	-0.04	0.23
Source of Information																
Radio	43.9	904	43.9	592	43.6	312	0.00	0.92	44.0	450	45.8	286	40.9	164	0.05	0.31
School lessons/teachers	15.8	904	14.9	592	17.6	312	-0.03	0.29	13.8	450	11.9	286	17.1	164	-0.05	0.14
Realized on my own	14.1	904	14.0	592	14.1	312	0.00	0.97	15.8	450	16.1	286	15.2	164	0.01	0.81
TV advertisement	10.0	904	10.3	592	9.3	312	0.01	0.63	8.9	450	8.0	286	10.4	164	-0.02	0.42
Family members and friends	6.5	904	5.9	592	7.7	312	-0.02	0.32	6.4	450	5.9	286	7.3	164	-0.01	0.58
Doctor/health worker	4.2	904	4.9	592	2.9	312	0.02	0.12	4.0	450	4.5	286	3.0	164	0.02	0.41
Self-help meeting	3.0	904	3.4	592	2.6	312	0.01	0.48	4.0	450	4.2	286	3.7	164	0.01	0.78
Other (posters/wall paintings, street plays/puppet shows)	2.5	904	2.7	592	2.2	312	0.01	0.67	3.1	450	3.5	286	2.4	164	0.01	0.52
Main action to reduce negative health impact of cooking																
Use cleaner burning fuels	26.7	904	28.4	592	23.4	312	0.05	0.10	25.6	450	28.0	286	21.3	164	0.07	0.11
Use cleaner stove	25.6	904	25.8	592	25.0	312	0.01	0.78	24.7	450	25.2	286	23.8	164	0.01	0.74
Keep children out of kitchen	13.5	904	13.7	592	13.5	312	0.00	0.93	11.8	450	11.9	286	11.6	164	0.00	0.92
Nothing	13.1	904	13.3	592	12.5	312	0.01	0.72	16.0	450	15.7	286	16.5	164	-0.01	0.84
Burn less firewood	7.1	904	6.4	592	8.3	312	-0.02	0.30	6.2	450	5.6	286	7.3	164	-0.02	0.48
Add chimney to stove	6.1	904	5.7	592	6.7	312	-0.01	0.56	6.9	450	6.6	286	7.3	164	-0.01	0.79
Cook outside	3.5	904	3.4	592	3.8	312	-0.01	0.72	4.4	450	3.8	286	5.5	164	-0.02	0.44
Other (Plant trees, awareness-generation programs)	4.4	904	3.3	592	6.8	312	-0.04	0.03	4.4	450	3.1	286	6.7	164	-0.04	0.11
Ever heard about cooking practices negatively impacting forests	63.7	1462	63.0	963	64.9	499	-0.02	0.47	59.1	775	57.3	506	62.5	269	-0.05	0.16
Ever heard about cooking practices negatively impacting local air quality	65.4	1462	64.8	963	66.7	499	-0.02	0.46	61.4	775	59.5	506	65.1	269	-0.06	0.13
Think that some stoves produce less smoke than others	84.9	1462	84.7	963	85.2	499	0.00	0.83	81.8	775	81.0	506	83.3	269	-0.02	0.43
Think that some fuels produce less smoke than others	87.7	1462	87.6	963	88.0	499	0.00	0.85	84.9	775	84.4	506	85.9	269	-0.02	0.58

When asked what actions can be taken to mitigate the negative health, environment and air quality impacts of cooking practices **primary cooks** indicated that to reduce negative health impacts they could use cleaner burning fuels (24.6%), do nothing (21.7%), use cleaner stoves (19.8), and keep children out of the kitchen (18.5%). To reduce negative impacts on forests main respondents indicated they should burn less firewood (28.0%), use cleaner burning fuels (22.7), and plant trees (17.1). To reduce air quality impacts main respondents suggested using cleaner burning fuels (38.5%), using cleaner stoves (18.5%), and plant trees (15.5%).

Perceptions and attributes of stoves and fuels

We asked both main respondents and primary cooks their opinions regarding whether some stoves and fuels produced less smoke than others. There were again striking differences in awareness of the influence of stove and fuel choices between main respondents and cooks. When asked if they think some stoves produce less smoke than others 84.9% of main respondents said 'yes' (vs. 37.9% of primary cooks). Eighty-eight percent of main respondents think that some fuels produce less smoke than others (vs. 39.3% of primary cooks).

We also asked main respondents to provide information on the best and worst attributes of their stoves and fuels. Thirty-one percent respondents reported speed of cooking as their stove's best attribute and 17.3% reported cost of stove. The second-best attributes of stoves are speed of cooking (21%) and ability to cook all foods (15.3%). The worst attributes of stoves are smoke produced (16.2%) and safety concerns (15.1%). The second-worst attributes of stoves are safety issues (15.5%) and durability (12.1%).

Approximately 25% of respondents reported smoke produced by fuel as its best attribute and 21.3% reported speed of cooking. Main respondents reported speed of cooking (24.8%) and availability (22.8%) as the second-best attributes of fuels used. The worst attributes of fuels are their lack of cleanliness (46.8%) and high cost (25.3%). The second-worst attributes of stoves are safety issues (22.9%) and lack of cleanliness (20.4%).

There is balance between treatment and control households on all indicators discussed above.

5.3.5 Typical Exposures and Risks

Over 41% households burn paraffin candle/lamp at least five times in the past month, 32% never burnt a lamp in the 30 days prior to the survey. Over 15% households burn trash, and, on average, the trash burning site is 0.6 meters away from the household. Three percent households own a small business that burns firewood or charcoal (control group has significantly higher percentage of households with this business (5%) compared to the treatment group (2.5%)). On average, 2.6% households have this biomass burning business within 50 meters of their household.

Table 5.3.4: Typical Exposures and Risks

	Full Sample			Treatment			Control			Diff T-C	p-value
	%	SD	N	%	SD	N	%	SD	N		
Frequency of household burning paraffin candle/lamp at night during last month											
Never	31.7		1462	30.9		963	33.1		499	-0.02	0.41
One or two times per month	8.9		1462	8.9		963	9.0		499	0.00	0.96
Three to four times per month	18.1		1462	17.9		963	18.6		499	-0.01	0.72
Five or more times per month	41.3		1462	42.3		963	39.3		499	0.03	0.27
Household burns rubbish	15.5		1462	14.6		963	17.0		499	-0.02	0.24
Number of times per month household burns rubbish	0.2	1.1	1462	0.2	0.8	963	0.3	1.5	499	-0.05	0.48
Number of meters trash burning is away from house	0.6	3.4	1462	0.6	3.4	963	0.6	3.5	499	0.05	0.79
Household has small business that involves burning wood or charcoal	3.4		1462	2.5		963	5.0		499	-0.03	0.02
Household within 50 meters of biomass burning business/industry that household	2.6		1462	2.4		963	3.0		499	-0.01	0.50

5.4 Young Child (Children Under 6 Years) Health

An important research question in the study is the effect of exposure to alternative cooking technology on children's health. To this end the survey instrument identifies whether any children routinely participate in cooking, or spend time with the main cook in the kitchen. A range of health symptoms are collected or young children related to respiratory illness, and eye and skin symptoms to capture these effects.

5.4.1 Health Card Status

Of the 818 children under 6 years in our study sample, 67% are taken care of by primary cooks (Table 5.4.1). Ninety percent young children have a health card, with children in control group households having significantly higher number of health cards (93.6%) compared to those in treatment group households (88.1%; p=0.02).

5.4.2 Asthma, Eczema and Allergic Rhinitis Symptoms

Approximately 18% young children ever had a wheezing or asthma attack, or experienced whistling in their chest; 16.2% experienced these symptoms in the last 12 months; and a majority (89.8%) of young children never experienced asthma or wheezing in the past 6 months.

Nineteen percent young children had itchy rashes that appeared and disappeared for periods that lasted up to 6 months; 15.3% young children had these rashes in many places.

Twenty-seven percent young children had sneezing, mucus or blocked nose problems in the past 12 months, and 17.3% young children had nose problems and itchy eyes in the past 12 months.

Table 5.4.1: Child (under 6 years) Health Indicators

	Full Sample		Treatment		Control		Diff T-C	p-value
	%	N	%	N	%	N		
Primary cook caregiver of child	67.0	818	67.2	522	66.6	296	0.01	0.87
Child has health card	90.1	818	88.1	522	93.6	296	-0.06	0.02
Wheezing/whistling in chest/asthma ever	17.7	818	16.9	522	19.3	296	-0.02	0.42
Wheezing/whistling in chest/asthma in the past 12 months	16.2	818	15.5	522	17.2	296	-0.02	0.55
Frequency of wheezing/whistling in chest/asthma in the past 6 months								
Never	89.8	818	90.4	522	88.9	296	0.02	0.50
Less than once a week	4.0	818	4.2	522	3.7	296	0.01	0.73
One or more times a week	3.3	818	2.9	522	4.1	296	-0.01	0.39
Once a month	2.9	818	2.5	522	3.3	296	-0.01	0.50
Itchy rash that appeared and disappeared for periods that lasted up to 6 months	19.3	818	17.8	522	22.0	296	-0.04	0.19
Itchy rash in many places	15.3	818	14.0	522	17.6	296	-0.04	0.23
Sneezing, mucus or blocked nose in the past 12 months	27.2	818	26.6	522	28.0	296	-0.01	0.70
Nose problem with itchy eyes in the past 12 months	17.3	818	15.7	522	19.9	296	-0.04	0.18
Ill with fever-past 12 months	62.5	818	60.7	522	65.9	296	-0.05	0.19
Ill with fever-past 2 weeks	26.8	818	25.5	522	29.1	296	-0.04	0.33
Respiratory infection in the past 12 months	21.8	818	22.0	522	21.6	296	0.00	0.90
Respiratory infection in the past 2 weeks	11.4	818	11.5	522	11.5	296	0.00	1.00
Illness with cough-past 12 months	70.0	818	70.1	522	69.6	296	0.01	0.89
Illness with cough-past 2 weeks	35.6	818	35.4	522	35.8	296	0.00	0.93
Difficulty breathing during illness with cough-past 2 weeks	19.5	818	20.1	522	18.2	296	0.02	0.55
Burns/Scalds in the past 12 months	8.3	818	9.4	522	6.4	296	0.03	0.13
Frequency of Burns/Scalds in the past 12 months								
Don't know	92.7	818	92.0	522	93.9	296	-0.02	0.29
Less than 1 time a month	6.1	818	6.7	522	5.1	296	0.02	0.32
One or more times a month	1.2	818	1.3	522	1.0	296	0.00	0.72
Burns/Scalds in the past 2 weeks	2.3	818	2.9	522	1.4	296	0.02	0.12
Seriousness of Burns/Scalds in the past 2 weeks								
None	97.6	818	97.1	522	98.6	296	-0.02	0.12
Light (No scar)	0.9	818	1.0	522	0.7	296	0.00	0.66
Moderate (scar smaller than a Fanta bottle top)	1.0	818	1.1	522	0.7	296	0.01	0.48
Serious (scar larger than Fanta bottle top)	0.5	818	0.8	522	0.0	296	0.01	
How did Burns/Scalds happen in the past 2 weeks								
None	97.7	818	97.1	522	98.7	296	-0.02	0.12
Fell in cooking fire	0.4	818	0.4	522	0.3	296	0.00	0.92
Burnt with hot object while cooking	0.7	818	1.0	522	0.4	296	0.01	0.25
Container with hot water/liquid spilled	0.6	818	0.7	522	0.3	296	0.00	0.40
Other non-cooking related	0.6	818	0.8	522	0.3	296	0.00	0.40
Burns/Scalds ever	5.3	818	6.1	522	3.7	296	0.02	0.13
Dry eyes in the past 12 months	22.3	818	22.8	522	21.3	296	0.02	0.65
Dry eyes in the past 2 weeks	13.5	818	12.5	522	15.2	296	-0.03	0.32
Diarrhea in the past 12 months	39.3	818	36.6	522	44.3	296	-0.08	0.05
Diarrhea in the past 2 weeks	15.7	818	13.8	522	19.3	296	-0.06	0.07

5.4.3 Respiratory and Flu-like Symptoms

Almost 22% children had a respiratory infection in the past 12 months, and 11.4% experienced the same in the past 2 weeks. A sizeable proportion of children (70%) had an illness with cough in the past 12 months, 35.6% in the past 2 weeks, and 19.5% young children experienced difficulty breathing during illness with cough, in the past fortnight.

Over half the young children in our study sample were ill with fever in the past 12 months (62.5%), and 26.8% were ill with fever in the past 2 weeks.

5.4.4 Burns

Of the total sample of 818 children, 5.3% had ever got burnt. A small proportion of young children (8.3%) got burnt in the past 12 months, with 6.1% of all the young children getting burnt less than once a month, and 1.2% one or more times a month. An even smaller proportion of young children (2.3%) got burnt in the 2 weeks prior to the survey; with 2% getting light (none) to moderate (smaller than a Fanta cap) scars. Two percent young children got burnt in cooking-related activities, and 1% in non-cooking related activities.

5.4.5 Eye Health and Other Symptoms

Nearly 22% young children experienced dry eyes in the past 12 months, 13.5% in the past 2 weeks. Thirty-nine percent young children experienced diarrhea in the past 12 months and 15.7% in the past 2 weeks.

Though there are no significant differences between the treatment and control groups in the full sample, in the sub-sample (n=112 young children), there are some differences. Non-occurrence of wheezing in the past 6 months was significantly higher among young children in the control group (98.6%) compared to those in the treatment group (84.6%; p=0.04). However, children in the treatment group had higher prevalence of illness with fever in the past 12 months (p=0.03) and past 2 weeks (p=0.00), dry eyes (p=0.04) and diarrhea (p=0.01) in the past 2 weeks, compared to those in the control group.

5.5 Disability and health problems of all household members

Besides collecting detailed health symptom prevalence among primary cooks and children under 6 years, we collect data on all household members' health insurance coverage and health status, as shown in table 5.5.1. Majority household members have mutual insurance (72%) and 12.8% have insurance from the Rwanda Social Security Board (RSSB).

Twenty-four percent members suffered a health problem in the 4 weeks prior to the survey. Among household members that suffered at least one serious health problem, acute respiratory infection is the most common (34.2%), followed by other household air pollution (HAP)-related problems such as asthma, chronic obstructive pulmonary disease (20.3%).

Of the 1856 household members that suffered any health problem in the past 4 weeks, 48.4% were unable to carry out their normal activities owing to their illnesses and 70% consulted a doctor. On average, household members were unable to perform activities of daily living for 5.8 days, with number of days being significantly higher for treatment group members (6.2) than control group members (5.2). Household members spent approximately 8,000 RWF on consultations and other fees related to illnesses and injuries. Forty-six percent household members rated themselves in 'good' health and 35.5% in 'very good' health. A significantly higher percentage of members in control group households report 'poor' general health in the last 12 months (4%) compared to those in treatment group households (2.4%), and a significantly higher percentage of members in treatment group households report 'excellent' general

health (7.7%) compared to those in control group households (5.1%). On average, majority household members (75%) perceive their health to have stayed the same over the past 12 months.

Table 5.5.1: All Household Members' Health Indicators

	Full Sample			Treatment			Control			Diff T-C	p-value
	%	SD	N	%	SD	N	%	SD	N		
Type of health insurance											
Mutual insurance	72.0		7702	71.3		5038	73.2		2664	-0.02	0.45
RSSB	12.8		7702	12.4		5038	13.6		2664	-0.01	0.54
Employer/Private	2.7		7702	3.0		5038	2.1		2664	0.01	0.32
MMI (for military)	0.8		7702	0.9		5038	0.5		2664	0.00	0.33
Other	1.9		7702	2.0		5038	1.6		2664	0.00	0.62
None	9.9		7702	10.3		5038	8.9		2664	0.01	0.40
Suffered any health problem-last 4 weeks	24.1		7702	23.8		5038	24.6		2664	-0.01	0.61
Nature of main health problem suffered-last 4 weeks											
Malaria	9.1		1856	9.7		1201	7.9		655	0.02	0.26
Internal parasites	14.7		1856	14.2		1201	15.7		655	-0.02	0.44
Acute respiratory infection	34.2		1856	33.9		1201	34.7		655	-0.01	0.81
Skin disease	1.8		1856	1.6		1201	2.3		655	-0.01	0.32
Accident/injury	2.6		1856	3.2		1201	1.4		655	0.02	0.01
Diarrhea	2.2		1856	2.2		1201	2.1		655	0.00	0.89
Dental problem	1.7		1856	1.7		1201	1.8		655	0.00	0.79
Gynaecological	2.3		1856	2.3		1201	2.3		655	0.00	0.96
Burns (major/minor)	0.2		1856	0.2		1201	0.2		655	0.00	0.64
Eye problems	3.8		1856	3.7		1201	4.0		655	0.00	0.76
Other respiratory illnesses	7.1		1856	6.7		1201	7.8		655	-0.01	0.51
Other	20.3		1856	20.5		1201	19.8		655	0.01	0.81
Unable to carry out normal activities due to illnesses/injuries-last 4 weeks	48.4		1856	48.0		1201	49.3		655	-0.01	0.64
Number of days unable to carry out normal activities-last 4 weeks	5.8	6.6	899	6.2	7.0	576	5.2	5.8	323	0.97	0.04
Consulted anyone for illnesses/injuries in the last 4 weeks	70.2		1856	69.9		1201	70.5		655	-0.01	0.84
Amount (in RWF) spent on consultations and other fees related to these illnesses and injuries	7986.0	23726.1	1302	7332.3	20157.0	840	9174.6	29103.2	462	-1842.36	0.23
Rate general health--last 12 months											
Poor	3.0		7702	2.4		5038	4.0		2664	-0.02	0.02
Fair	8.7		7702	9.1		5038	7.9		2664	0.01	0.32
Good	46.0		7702	45.9		5038	46.2		2664	0.00	0.88
Very good	35.5		7702	34.9		5038	36.7		2664	-0.02	0.50
Excellent	6.8		7702	7.7		5038	5.1		2664	0.03	0.04
Health improvement-last 12 months											
Improved	17.0		7702	15.8		5038	19.4		2664	-0.04	0.07
Stayed the same	75.0		7702	76.4		5038	72.4		2664	0.04	0.07
Became worse	8.0		7702	7.9		5038	8.1		2664	0.00	0.80

5.6 Health of Primary Cook

5.6.1 Cooking History and Current Cooking

Although degrees of cooking experience vary, on average primary cooks have considerable experience: the average time the cook has spent as a primary cook in any household is 11.9 years, and the average time as a primary cook in the present household is 6.5 years. Primary cooks largely grew up in households that used traditional three-stone or three-brick stoves (67.6%). Twenty-seven percent grew up in households that used portable charcoal stoves. The majority of primary cooks also grew up in households where cooking was done primarily indoors (82.8%), as opposed to outdoors. Cooks often work alone, with 51.7% of primary cooks reporting that they usually have nobody helping them with cooking. Having another adult (>=15 years) in the household help with cooking is reported in 41.4% of households. Only 6.5% of households report having a child under the age of 15 help with cooking. In most cases (5.4%) female (vs. male) children help with cooking. The average number of meals cooked in the household the day prior to the survey is 2.3; the average number of times water was boiled in the house the day prior to the survey was 1.3.

5.6.2 Blood pressure and anthropometric measurements

On average, primary cooks have diastolic blood pressure of 78.3 mm/Hg, systolic blood pressure of 119.7 mm/Hg and average pulse rate (i.e. number of heart beats per minute) is 73.9 bpm. The average height for primary cooks in our sample is 162.2 cm and on average cooks weigh 65 kg. There are no significant differences in blood pressure or anthropometric measurements between treatment and control group primary cooks.

5.6.3 Burns and Scalds

The prevalence of burns and scalds among primary cooks is 19.2% over the past 12 months. For some, burns and scalds are a fairly regular occurrence; 4.6% of primary cooks experienced a burn at least once a month during the past 12 months. Twelve percent of primary cooks indicated they had experiences a burn or scald in the past 2 weeks. Of those that experienced burns, 49% had no scarring; 43% had moderate burns (scarring and smaller than Fanta bottle top); and 8% had serious burns (scarring and larger than a Fanta bottle top). In the vast majority of cases burns are related to cooking. Forty-eight percent of primary cooks were burned by a hot object while cooking, 29% were burned when a container of hot water/liquid spilled; 10% fell in the cooking fire or had some other cooking related incident. Only 3% of burns or scalds were not cooking related.

Table 5.6.1: Primary Cook Health Indicators – Burns

	Full Sample		Treatment		Control		Diff T-C	p-value
	%	N	%	N	%	N		
Burns in last 12 months	19.2	1462	19.7	963	18.2	499	0.02	0.49
Burns Frequency								
Never	81.2	1462	80.6	963	82.4	499	-0.02	0.40
Less than once a month	14.6	1462	14.7	963	14.4	499	0.00	0.87
More than once a month	4.2	1462	4.7	963	3.2	499	0.02	0.16
Burns/Scalds in the past 2 weeks	12.0	1462	13.1	963	9.8	499	0.03	0.06

Table 5.6.1: Primary Cook Health Indicators – Burns (continued)

	Full Sample		Treatment		Control		Diff T-C	p-value
	%	N	%	N	%	N		
Severity of burn								
None	81.7	1462	81.4	963	82.4	499	-0.01	0.65
Light (No scar)	9.3	1462	9.4	963	9.0	499	0.00	0.79
Moderate	7.4	1462	7.6	963	7.0	499	0.01	0.69
Serious	1.6	1462	1.6	963	1.6	499	0.00	0.95
Reason for getting burnt								
None	81.7	1462	81.3	963	82.4	499	-0.01	0.62
Fell in cooking fire	1.6	1462	1.3	963	2.2	499	-0.01	0.26
Burnt with hot object while cooking	8.4	1462	8.5	963	8.0	499	0.01	0.74
Container with hot water/liquid spilled while cooking	5.4	1462	5.4	963	5.4	499	0.00	0.99
Other cooking related	2.1	1462	2.3	963	1.6	499	0.01	0.36
Other non-cooking related	0.9	1462	1.1	963	0.4	499	0.01	0.10

5.6.4 Cardiopulmonary, Respiratory and Flu-like symptoms

Shortness of breath is the most common cardiopulmonary health symptom that primary cooks in our study experienced (35.6%), as seen in Table 5.6.2. The other common health symptoms in this category are chest infection (24.2%), difficulty breathing (17.3%) and wheezing or whistling in chest (9.4%).

Less than 20% primary cooks experienced respiratory health symptoms of chronic cough (18.1%) and night phlegm (13.4%) in the past 12 months.

Over 56.3% primary cooks have experienced fatigue in the 12 months prior to the survey, and 31% have experienced fever or chills in the same time frame.

Table 5.6.2: Primary Cook Health Indicators – Cardiopulmonary and Respiratory Symptoms in past 12 months

	Full Sample		Treatment		Control		Diff T-C	p-value
	%	N	%	N	%	N		
Cardiopulmonary Symptoms								
Chest Infection	24.2	1462	24.0	963	24.6	499	-0.01	0.78
Shortness of breath	35.6	1462	35.0	963	36.9	499	-0.02	0.48
Difficulty breathing/chest tightness	17.3	1462	16.7	963	18.4	499	-0.02	0.42
Wheezing/whistling in chest	9.4	1462	8.5	963	11.0	499	-0.03	0.13
Sleep disturbed by wheezing/whistling in chest	7.6	1462	7.1	963	8.6	499	-0.02	0.30
Woken up in morning with chest tightness/pressure	7.6	1462	6.6	963	9.4	499	-0.03	0.07
Respiratory Symptoms								
Chronic cough	18.1	1462	18.2	963	18.0	499	0.00	0.95
Phlegm at night in the	13.4	1462	13.1	963	14.2	499	-0.01	0.55

5.6.5 Neurologic Symptoms

Over a quarter primary cooks in our sample report experiencing headache in the past 12 months (76%), 61% experienced forgetfulness, 48% experienced difficulty concentrating, and 40% experienced dizziness in the past 12 months. The comparison between the treatment and control samples is found in Table 5.6.3.

Table 5.6.3: Primary Cook Health Indicators – Neurologic Symptoms in past 12 months

	Full Sample		Treatment		Control		Diff T-C	p-value
	%	N	%	N	%	N		
Headache	75.6	1462	76.1	963	74.7	499	0.01	0.57
Difficulty concentrating	47.5	1462	46.3	963	49.7	499	-0.03	0.22
Forgetfulness	60.7	1462	60.5	963	61.1	499	-0.01	0.83
Dizziness	40.3	1462	41.0	963	38.9	499	0.02	0.43

5.6.6 Skin Irritation, Eye Health, Allergy and Other Symptoms

Twenty percent primary cooks experienced skin irritation without rash in the past 12 months. Less than half the primary cooks in our study sample (47.2%) experienced irritated, burning or watery eyes in the past 12 months, and 14.4% report green, sticky secretion from eyes in the same time duration (Table 5.6.4). Majority of the primary cooks report vision never affecting either household activity (74.5%) or cooking ability (78.2%).

Table 5.6.4: Primary Cook Health Indicators – Eye Problems

	Full Sample		Treatment		Control		Diff T-C	p-value
	%	N	%	N	%	N		
Irritated, burning and watery eyes in the last 12 months	47.2	1462	47.8	963	46.1	499	0.02	0.54
Green sticky secretion from eyes in last 12 months	14.4	1462	13.4	963	16.2	499	-0.03	0.15
Vision affecting household activity								
Never	74.5	1462	75.6	963	72.5	499	0.03	0.21
Seldom	12.8	1462	12.1	963	14.0	499	-0.02	0.32
Often	9.0	1462	8.4	963	10.2	499	-0.02	0.27
Always	3.6	1462	3.8	963	3.2	499	0.01	0.53
Vision affecting cooking ability								
Never	78.2	1462	78.8	963	77.0	499	0.02	0.42
Seldom	10.7	1462	10.8	963	10.6	499	0.00	0.92
Often	7.3	1462	6.9	963	8.0	499	-0.01	0.43
Always	3.8	1462	3.5	963	4.4	499	-0.01	0.42

Twenty-one percent primary cooks experienced sneezing, mucus or blocked nose problems in the past 12 months. A very small percentage of primary cooks (9.8%) ever experienced an itchy rash that appeared and disappeared for periods that lasted a minimum of 6 months. Twenty-four percent cooks report non-pregnancy related nausea or vomiting in the 12 months before the survey.

There are no significant differences in prevalence of health symptoms across all the aforementioned categories between primary cooks in treatment and control group households.

5.6.7 Smoking, Alcohol, Salt and Physical Activity Exposure

A large percentage of primary cooks had never consumed alcohol (62.5%) and less than 10% ever smoked cigarettes (7.3%). Over 33% primary cooks report adding salt to their food.

5.6.8 Exposures and Risks

Table 5.6.5 shows typical exposures and risks experienced by primary cooks. Fifteen percent primary cooks burn trash, and on average, cooks burn trash twice a month. Less than 3% cooks live within 50 meters of a biomass burning industry, such as beer brewing, brick making, cooking, hotel or poultry farm. Electricity is the most common source of lighting in the living area, (91.4%); small sticks or fuelwood and plastic bags/ or flip flops are the most common sources of lighting stoves (40.3% and 27.6%, respectively). A significantly higher percentage of primary cooks in control group households use fuelwood for lighting their stoves (44.5%) than those in treatment group households (38.2%), while a significantly higher percentage of primary cooks in treatment group households use kerosene for lighting their stoves (3.1%) than those in control group households (1.2%).

Table 5.6.5: Primary Cooks' Typical Exposures and Risks

	Full Sample			Treatment			Control			Diff T-C	p-value
	%	SD	N	%	SD	N	%	SD	N		
Burn trash	15.1		1462	14.8		963	15.6		499	-0.01	0.69
Number of times per month burn trash	2.0	0.9	1462	2.0	1.1	963	1.9	0.5	499	0.42	0.13
Living within 50 meters of a biomass burning industry	2.5		1462	2.7		963	2.0		499	0.01	0.39
Source of lighting in living area											
Kerosene	4.9		1462	5.6		963	3.6		499	0.02	0.07
Electricity	91.4		1462	91.0		963	92.0		499	-0.01	0.51
Candles	2.7		1462	2.4		963	3.2		499	-0.01	0.38
Stove	0.2		1462	0.2		963	0.2		499	0.00	0.98
Other	0.9		1462	0.8		963	1.0		499	0.00	0.75
Source of lighting stove											
Small sticks/fuelwood	40.3		1462	38.2		963	44.5		499	-0.06	0.02
Grass/reeds/straw	15.5		1462	15.6		963	15.4		499	0.00	0.94
Plastic bag/flipflop	27.6		1462	27.6		963	27.5		499	0.00	0.95
Kerosene	2.5		1462	3.1		963	1.2		499	0.02	0.01
Matches	8.8		1462	8.9		963	8.4		499	0.01	0.74
Neighbors' fire	1.4		1462	1.6		963	1		499	0.01	0.35
Candles	2.9		1462	3.9		963	1		499	0.03	0.00
Electricity	0.7		1462	0.6		963	0.8		499	0.00	0.71
Cloth or Paper	0.3		1462	0.4		963	0.2		499	0.00	0.46

5.7 Consumption and Wellbeing

5.7.1 Main Respondents

Consumption (Food and Non-food)

A key research question in this study is the extent to which the Inyenyeri cook stove model yields savings in terms of fuel costs, thus allowing households to increase their overall well-being. Following a large literature in economics on the measurement of well-being, we collected a detailed expenditure module that was based on the Rwanda Living Conditions Survey and covered over 150 detailed expenditure items. We use these data to build a comprehensive consumption aggregate.

The top panel of Table 5.7.1 reports the mean total per capita monthly consumption expenditure for households in the sample, as well as means for food and non-food expenditure. Mean expenditures are RWF 70,648, which, at an exchange rate of RWF 720 to the US dollar, implies a daily per person consumption of US$3.50. Food represents on average 37 percent of overall consumption with a mean of RWF 25,202.

Consumption tends to be skewed to the right, and the data from this sample is no different (as indicated in Figure 1, which shows the density of consumption for the intervention and control groups). Median consumption at RWF 56,532 is significantly lower than the mean as a result of this skewness, and at the median, consumption is closer to US$2.80 per person per day. When we exclude the top 1 percent of values mean consumption in the entire sample goes from US$3.50 to US$3.30 per person per day.

To give a rough assessment of how well off our sample is, we inflate the national poverty line of RWF118,000 per adult per year in 2011 units using the Consumer Price Index (CPI) as reported by the IMF. The implied inflator is 1.22 and the resulting poverty line in July 2015 units is RWF143,535. When we annualize our measure of consumption, only 3 percent of people live in households below this poverty line, and virtually nobody (1.5 percent of the sample) lives in a household below the extreme poverty line, which is defined as 70 percent of the poverty line. By comparison, the poverty rate in 2011 in Rwanda was 45 percent overall and 22 percent in urban areas.

Figure 5.7.1: Baseline Per Capita Consumption

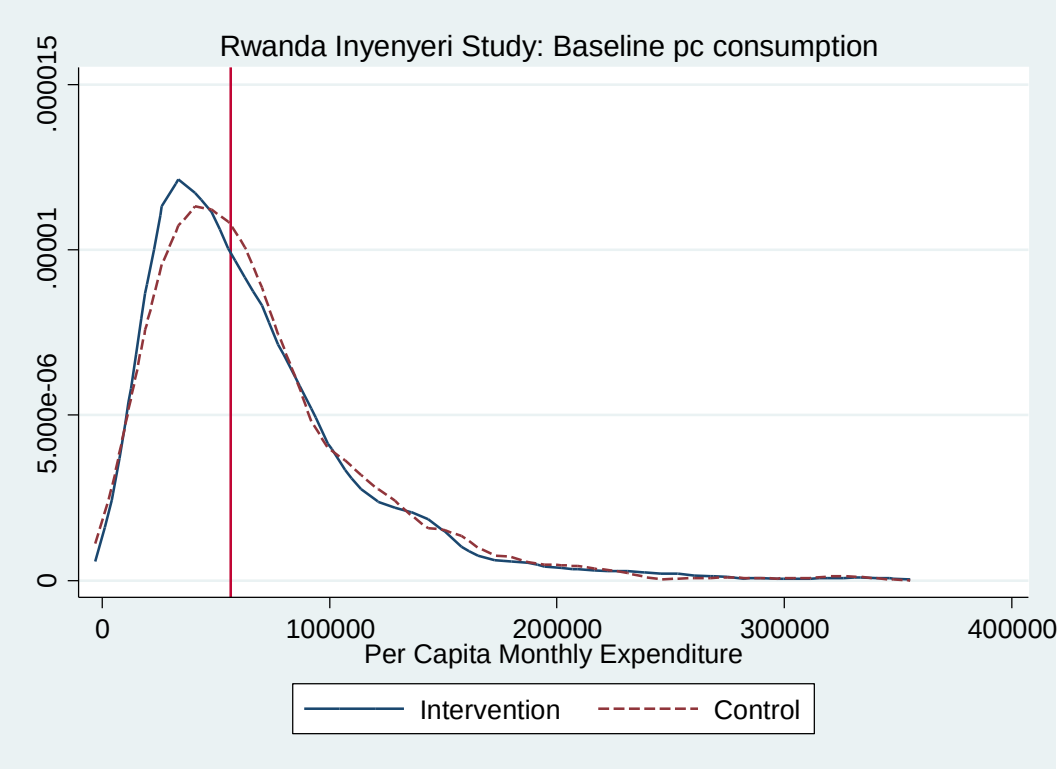
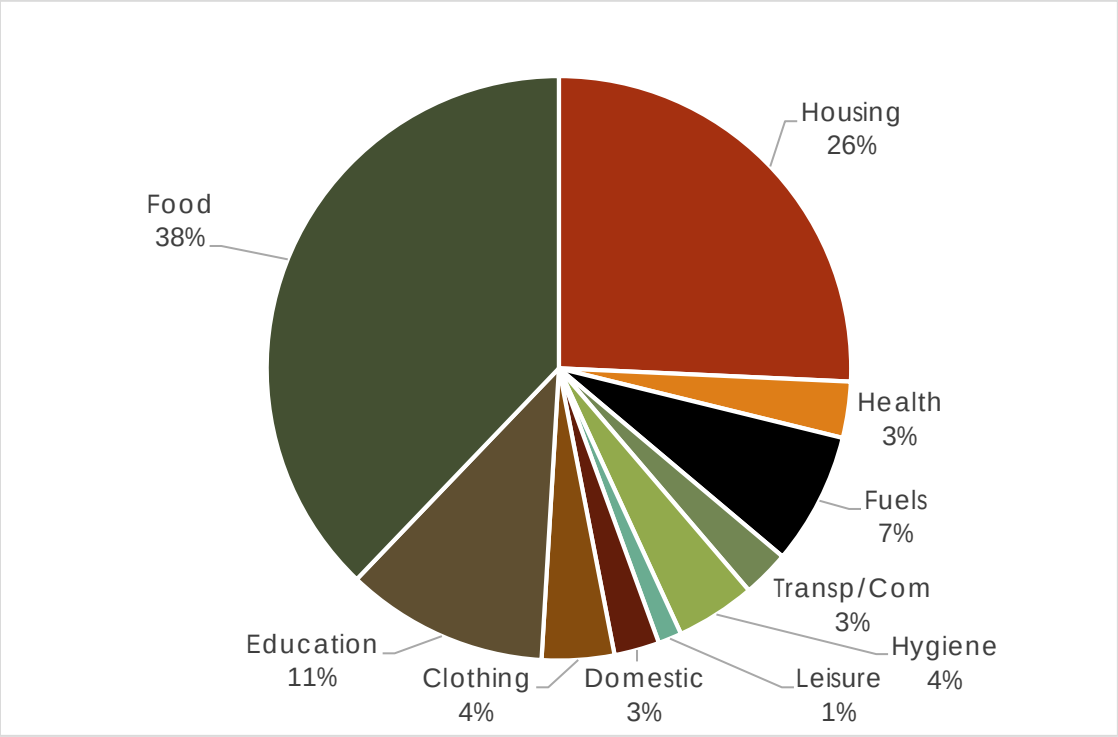


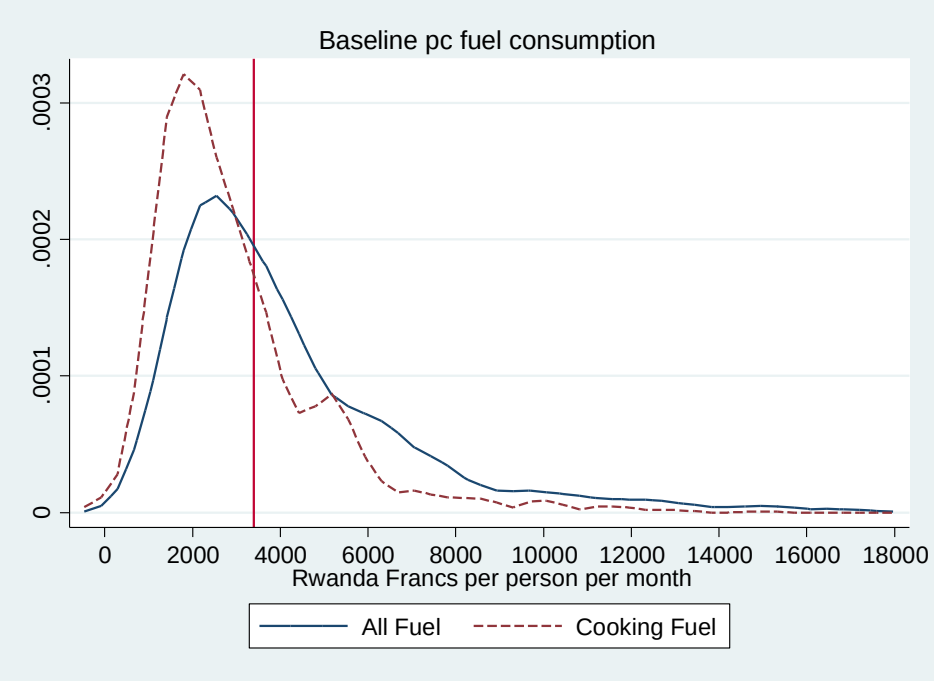
Table 5.7.1 also reports consumption by broad consumption categories as well as budget shares (third panel) which are more intuitive to interpret. The largest components of the budget are for food (38 percent), housing (26 percent), education (11 percent) and fuels (7 percent). Cooking fuels alone account for 5 percent of the budget—the fourth largest component overall. These budget shares are depicted graphically in Figure 5.7.2.

Figure 5.7.2: Budget share



As our main interest in this study is in fuel consumption, Figure 5.7.3 displays the densities for total and cooking fuel in our sample, with a vertical line at the median value of total fuel. Since total fuel includes cooking fuel its density is shifted to the right.

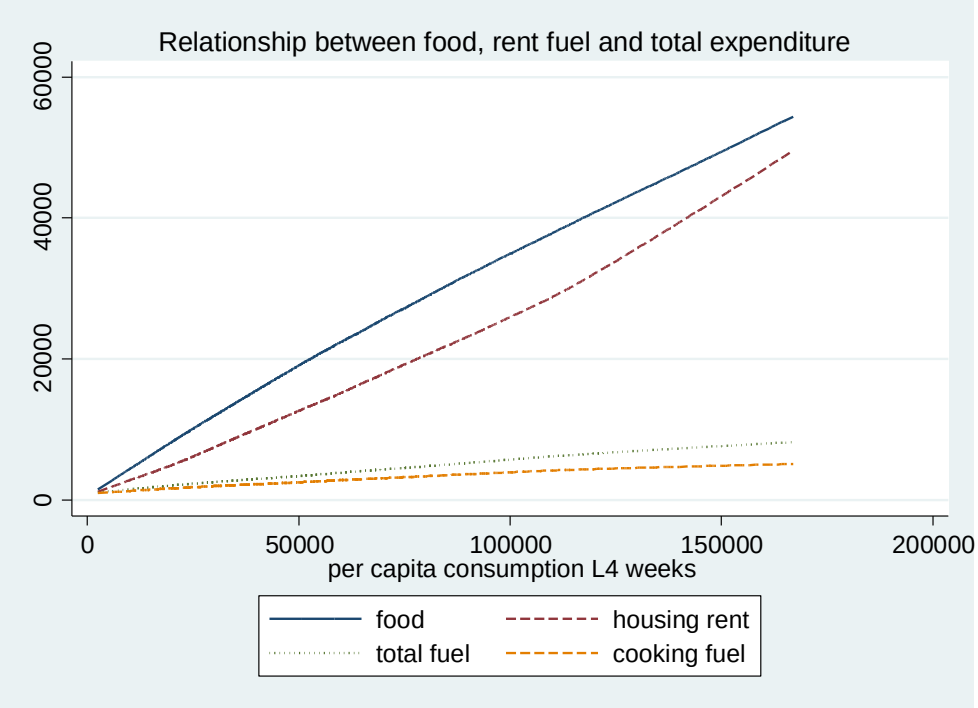
Figure 5.7.3: Baseline Per Capita Fuel Consumption



A key analytical concept in economics is the Engel curve, which summarizes how spending on a particular item increases as overall household income increases. Figure 5.7.4 traces the Engel curves for total and cooking fuel as well as for the two largest components of the budget—food and housing. The

slope for the latter two items is quite steep relative to the slope for fuel. This implies that as households get richer, they spend less of their *additional* income on fuels, and more on housing and food. This implies that fuel is a basic need—that households prioritize fuels as part of their essential basket of consumption, and as they get richer, they then have more money to devote to other non-essential or 'luxury' items.

Figure 5.7.4: Relationship between Food, Rent Fuel, and Total Expenditure



The concepts of basic needs or staple versus luxury items are summarized in economics by the income elasticity of demand for an item. The income elastic describes how much of an increase in income is devote to a particular item. For basic needs or staples, very little additional income is spent on that item and the elasticity is less than 1, while for luxury goods, more of additional income is devoted to their consumption and so their elasticity is greater than one.

We estimate the elasticity of demand for each of our ten consumption groups using the well-known Working-Leser functional form, for which applications can be found in Deaton & Muellbauer (1980) and Handa (1996). This specification looks like the following:

$$(1) \qquad w_i = \alpha + \beta_1 X_1 + \beta_2 \ln(\text{PCEXP}) + \beta_3 \sum(AGEGROUPS) + \varepsilon_i$$

where w_i is the budget share for commodity i, PCEXP is household per capita monthly consumption expenditures, and AGEGROUPS represent a vector of variables indicating the number of household residents in each of 14 mutually exclusive age groups. A main benefit of employing this specification is that it automatically imposes the budget constraint because the shares on the left-hand side must all sum to one.

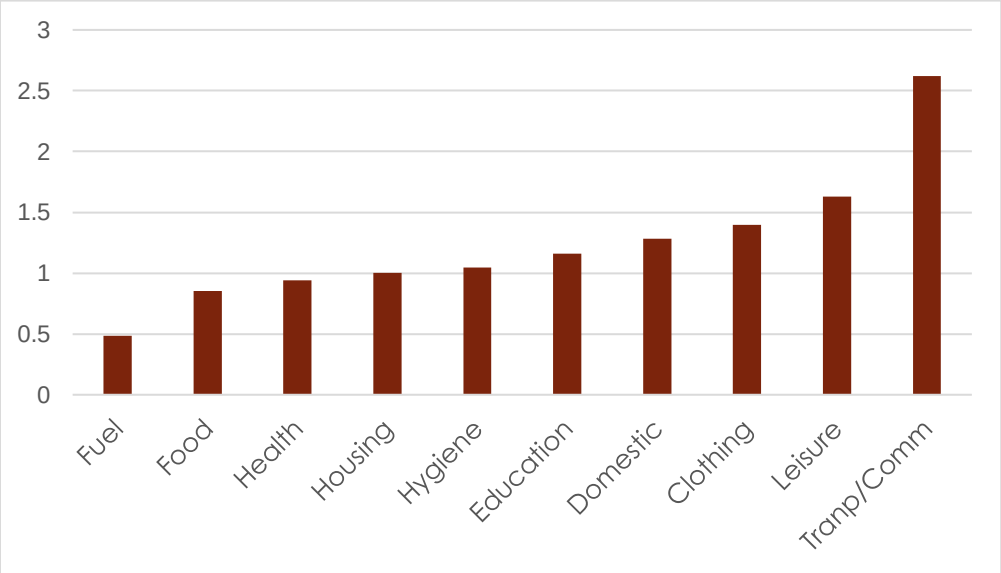
Using equation (1), the marginal effect on the budget share of a change in total household expenditure is given by (3), while the total expenditure elasticity can be derived using the formula in (4) (Deaton, Ruiz and Thomas 1989):

$$(3) \qquad \partial w_i / \partial \ln(PCEXP)) = \beta_2$$

$$(4) \qquad E_i = 1 + \frac{\left[\frac{\partial w_i}{\partial \ln(\text{PCEXP})}\right]}{w_i} = 1 + \left[\frac{\beta_2}{w_i}\right]$$

Note that the elasticity calculation set out in equation (4) is based on the budget share out of total expenditure and not income, and so these are more accurately referred to as total expenditure elasticities. The estimated elasticities for our ten consumption groups are shown in Figure 5. The coefficient of PCEXP is not statistically significant for hygiene, health and rent so we do not give much weight to those elasticity estimates. *For our purposes however, the striking result in this figure is that the elasticity for fuel is a mere 0.49, the lowest among all the consumption groups, and lower even than the elasticity for food which is 0.85. In other words, fuel is considered even more of a staple or basic need for these households than food!* The other elasticity estimates in Figure 5 are quite intuitive, with transportation and communication, leisure and clothing appearing to be very strong 'luxury' items, housing, health and hygiene with unitary elasticity, and food a staple item.

Figure 5.7.5: Total expenditure elasticity by consumption group



Credit and Savings

On average, households owned 7.1 durable goods. The assets asked about in the survey included living room furniture, refrigerator, freezer, radio, television set, satellite dish, cooker, video or DVD player, computer and accessories, music system, electric fan, air-conditioner, sewing machine, bed, cupboard and bookcase, table-chair, car, motorcycle (for home use only) and bicycle (for home use only).

A vast majority of the households in our study sample save with a savings institution (83.6%), and close to 19% households have a household member with outstanding debt. Treatment households have a significantly higher percentage (20.7%) of such members compared to control households (14.6%) (p=0.00). On average, the total amount outstanding on loans is 7,074,515.5 RWF (~9,483 USD). Among the 19.6% households with members that purchased anything on credit, the total amount outstanding is 1,432,424.3 RWF (~ 1920 USD). There are no significant differences between treatment and control households on any of these indicators.

Table 5.7.1 Consumption (in RWF) Indicators: Balance between Treatment and Control Groups at Baseline

	Full Sample N=1462)		Treatment (N=963)		Control (N=499)		Diff T-C	p-value
	Mean	SD	Mean	SD	Mean	SD		
Expenditure categories (last 4 weeks)								
Per capita total consumption	70648.510	58404.390	70260.248	58297.920	71608.542	58657.690	-1348.30	0.68
Per capita food consumption	25202.549	20598.970	25281.332	21359.550	25116.168	19065.810	165.16	0.88
Per capita non-food consumption	45445.962	41982.210	44978.916	40908.790	46492.375	44004.690	-1513.46	0.52
Non-food expenditure categories per capita (last 4 weeks)								
Monthly housing rent	18887.402	22829.610	18901.920	22261.470	18955.134	23910.710	-53.21	0.97
Healthcare	2021.350	5851.079	1833.989	5026.325	2394.104	7171.241	-560.12	0.12
Total fuel (cooking and other fuel)	4359.581	3628.743	4471.290	3909.465	4165.322	3007.428	305.97	0.10
Of which cooking fuel	3078.717	2341.109	3156.544	2475.214	2939.050	2052.531	217.49	0.07
Personal care and hygiene	3155.201	4192.070	3087.298	3975.778	3285.668	4582.078	-198.37	0.41
Entertainment and leisure	1163.973	3170.610	1235.258	3327.194	1024.321	2842.207	210.94	0.21
Clothing	3286.858	7274.169	3380.474	7709.927	3099.607	6352.529	280.87	0.46
Education (past academic year)	7032.617	9709.219	7101.086	9407.213	6910.138	10275.530	190.95	0.73
Budget shares to non-food expenditures								
Monthly housing rent	0.257	0.127	0.258	0.128	0.256	0.126	0.00	0.69
Healthcare	0.031	0.066	0.030	0.063	0.034	0.071	0.00	0.28
Total fuel (cooking and other fuel)	0.073	0.040	0.074	0.040	0.070	0.040	0.00	0.10
Of which cooking fuel	0.054	0.034	0.055	0.034	0.053	0.035	0.00	0.16
Transport and communications	0.026	0.073	0.022	0.066	0.034	0.084	-0.01	0.01
Personal care and hygiene	0.044	0.033	0.043	0.032	0.045	0.035	0.00	0.55
Entertainment and leisure	0.013	0.033	0.014	0.037	0.011	0.022	0.00	0.03
Domestic and household items	0.025	0.033	0.025	0.033	0.026	0.033	0.00	0.46
Clothing	0.040	0.063	0.040	0.063	0.040	0.064	0.00	0.94
Education (past academic year)	0.112	0.122	0.114	0.123	0.107	0.121	0.01	0.31
Budget shares to food expenditures								
Total food	0.378	0.126	0.379	0.125	0.377	0.129	0.00	0.78
Food and drink consumed outside	0.028	0.062	0.026	0.058	0.031	0.070	0.00	0.27
Sugar, oils and spices	0.141	0.055	0.144	0.057	0.136	0.051	0.01	0.01
Beverages (including alcohol)	0.048	0.051	0.048	0.053	0.047	0.048	0.00	0.80
Roots and tubers	0.102	0.075	0.103	0.073	0.100	0.078	0.00	0.61
Vegetables	0.107	0.049	0.107	0.050	0.108	0.049	0.00	0.60
Fruits	0.085	0.052	0.083	0.050	0.087	0.054	0.00	0.23
Meat/poultry/fish/dairy	0.180	0.104	0.176	0.103	0.187	0.106	-0.01	0.05
Cereal	0.229	0.108	0.232	0.111	0.224	0.101	0.01	0.14

5.8 Economic Activity and Productive Assets

5.8.1 Household Enterprises

In 49.3% of our sample of 1462 households, at least one household member operates a non-farm income-generating enterprise in the past 12 months. These enterprises include brick or charcoal-making, masonry, firewood selling, metalwork, tailoring, repair work, food processing, petty trading, and food selling and trading, among others. Among these households, 86.3% own one enterprise, while the remaining (13.7%) own two enterprises. Among households with only one enterprise, the most common types of business are financial services and property rentals (17.6%) and tuck shops (17.6%), followed by grocery or bottle shops (16.9%). Among households with a second enterprise, financial services and property rentals are also most common (32.3%). Approximately 8% households own bottle and grocery shops, and transportation services. Households with only one enterprise have owned the business for an average of 6.4 years, while those with two have owned the business for an average of 5.9 years.

Households that own more than one enterprise report higher profit margins on average on the second enterprise (88.9% profit) than the first enterprise (68.2% profit), with 13% of the first and 4% of second enterprises breaking even. The first enterprise is reported to bring in more revenue and incur more losses. On average, the profits earned from the first and second enterprises are RWF 171,035 and RWF 124,944 respectively. The average losses incurred by households on the first and second enterprises are RWF 303,484 and RWF 153,333. There are no significant differences between treatment and control households on any of these indicators of economic activity.

Table 5.8.1 Household Enterprises Indicators

	Full Sample		Treatment		Control		Diff T-C	p-value
	%	N	%	N	%	N		
Over past 12 months, anyone in hh operated any (non-farm) income-generating enterprises	49.3		49.3		49.5	499	-0.002	0.95
Number of HH enterprises								
One	86.3	722	86.9	475	85.0	247	0.02	0.48
Two	13.7	722	13.1	475	15.0	247	-0.02	0.48
Years of Existence (Enterprise #1)	6.4	722	6.5	475	6.3	247	0.22	0.67
Months of Existence (Enterprise #1)	1.1	722	1.0	475	1.2	247	-0.19	0.29
Years of Existence (Enterprise #2)	5.9	99	6.1	62	5.6	37	0.48	0.68
Months of Existence (Enterprise #2)	1.0	99	1.0	62	0.9	37	0.07	0.89
Profit/Loss (Enterprise #1)								
Profit	68.2	722	68.4	475	68.0	247	0.00	0.91
Loss	18.7	722	18.9	475	18.2	247	0.01	0.81
Break-even	13.0	722	12.6	475	13.8	247	-0.01	0.67
Profit/Loss (Enterprise #2)								
Profit	88.9	99	88.7	62	89.2	37	-0.005	0.942
Loss	7.1	99	6.5	62	8.1	37	-0.02	0.76
Break-even	4.0	99	4.8	62	2.7	37	0.02	0.58

5.8.2 Land and Livestock Ownership

Seventy-nine percent of households do not own any land. Among those that do, 8.9% own more than a hectare (average of 1.3 hectares), 7.8% own less than a hectare (average of 0.03 hectares) and 4.2% own a hectare. Approximately 21% households have raised livestock in the past 12 months; the households that reported livestock ownership owned an average of 4.2 cattle, 2.3 chickens and 0.6 goats. The most commonly purchased livestock (in the past 12 months before the survey) are chickens (30.6%), pigs (26.7%), goats (19%), cattle (15.3%) and rabbits (14.8%). Of the households that have purchased livestock in the past 12 months, on average, households purchase 5.3 chickens, 4.8 pigs, 4.3 cattle and 3 sheep. Cattle were valued most highly (RWF 703,680) followed by pigs (RWF 352,250).

Except for the number of pigs owned in the past 12 months in the treatment group being significantly higher (0.3) than those in the control group (0.1) (p=0.02), there were no other significant differences between treatment and control groups on the indicators of productive assets described above. (Results available upon request)

5.9 Time Use

5.9.1 Time Use of All Household Members

The main respondent was asked about the time use and labor practices of all household members 10 years and older, including domestic chores, agriculture, livestock or fisheries, non-agricultural activities and participation in wage and non-wage labor. In Table XX we present the average time spent in each activity by household members in each age group. For all activities the reference period is the past 7 days.

Domestic Chores

Children (10-17 years), on average, spent 0.6 hours collecting water, 0.9 hours cooking, 1.9 hours cleaning or in child care, and no time in firewood collection or fuel material (such as *uribingo*, grass and charcoal) production. Maximum time spent in water collection among children was by those aged 10-13 years (0.7 hours); children between the ages of 14-17 years spent 0.6 more hours cooking than children aged 10-13 years; and children in the 14-15 year age group spent 1.4 more hours in childcare or cleaning activities compared to those in the 10-13 year age group. Except for childcare or cleaning (p=0.03), there were no significant differences between treatment and control groups in time spent performing domestic chores, among all children.

There is variation in the amount of time adults in different age groups spent performing domestic chores and other activities. Water collection was mainly done by adults aged 18-24 years (0.4 hours), followed by adults aged 25-34 years (0.2 hours), and those in the 35-44 year age group and 65 years and older (0.1 hours). Similar to the findings among children, adults too, on average, spent no time in firewood collection or production of other fuel materials. Cooking was mainly done by adults in the 18-24 years age group (1.8 hours), followed by those aged 35-44 years (1.7 hours), 25-34 years (1.6 hours), 45-54 years and 55-65 years (1.2 hours). Adults in the 25-34 years age group mainly performed chores of childcare or cleaning (5.5 hours), followed by those aged 35-44 years (4.2 hours), 18-24 years (3.2 hours), and 45-54 years (1.5 hours). Older adults spent less than an hour in the past week in childcare or cleaning chores.

There is evidence of a significant gender divide in cooking and childcare or cleaning activities. Girls (aged 10-17 years) spent significantly (p=0.00) more time cooking (1.4 hours) and cleaning or in childcare (2.6 hours) compared to boys (0.3 hours and 1 hour, respectively). Likewise, adult women, on

average, spent significantly (p=0.00) more time cooking and in childcare or cleaning (3 hours and 6.2 hours, respectively) compared to men (0.5 hour and 1.4 hours, respectively). There were no statistically significant differences between males and females in the number of hours spent on other domestic chores.

Agriculture/Livestock/Fisheries

On average, children spent 0.1 hours in the past week performing agricultural activities, with children in the 10-13 year age group spending maximum time (0.2 hours) compared to those in the 14-15 year age group (0.1 hours). Adults in the 55-64 years age group spent maximum time in these activities (3.1 hours), followed by those in the 45-54 years age group (1.6 hours). Adults in other age groups spent 1 hour or less in the same. There were no statistically significant differences between males and females, and between treatment and control groups in agriculture and allied activities.

Table 5.9.1: Household Members' Time Use (in hours) Indicators: Balance between Treatment and Control Groups at Baseline

	Full Sample			Treatment			Control			Diff	p-
	Mean	SD	N	Mean	SD	N	Mean	SD	N	T-C	value
Domestic Chores (last 7 days)											
Water collection - All household members	0.3	1.6	5284	0.4	1.6	3460	0.3	1.6	1824	0.11	0.09
Male	0.3	1.6	2834	0.4	1.7	1858	0.3	1.5	976	0.12	0.13
Female (p=0.6033)	0.3	1.5	2450	0.4	1.5	1602	0.3	1.6	848	0.11	0.13
All children (10-17 years)	0.6	2.1	1684	0.6	2.0	1093	0.4	2.2	591	0.20	0.22
All adults (18 years and above)	0.2	1.3	3600	0.3	1.3	2367	0.2	1.1	1233	0.08	0.16
Firewood collection - All household members	0.0	0.3	5284	0.0	0.4	3460	0.0	0.2	1824	0.00	0.79
Male	0.0	0.4	2834	0.0	0.5	1858	0.0	0.2	976	0.01	0.41
Female (p=0.2472)	0.0	0.2	2450	0.0	0.1	1602	0.0	0.3	848	-0.01	0.39
All children (10-17 years)	0.0	0.5	1684	0.0	0.6	1093	0.0	0.1	591	0.02	0.36
All adults (18 years and above)	0.0	0.2	3600	0.0	0.2	2367	0.0	0.3	1233	-0.01	0.61
Production of other fuel materials (uribingo, grass and charcoal) - All household members	0.0	0.4	5284	0.0	0.4	3460	0.0	0.2	1824	0.02	0.07
Male	0.0	0.2	2834	0.0	0.3	1858	0.0	0.1	976	0.01	0.17
Female (p=0.0347)	0.0	0.5	2450	0.0	0.6	1602	0.0	0.2	848	0.02	0.18
All children (10-17 years)	0.0	0.6	1684	0.1	0.7	1093	0.0	0.2	591	0.05	0.05
All adults (18 years and above)	0.0	0.2	3600	0.0	0.2	2367	0.0	0.2	1233	0.00	0.80
Cooking - All household members	1.3	3.7	5284	1.4	3.8	3460	1.2	3.4	1824	0.19	0.07
Male	0.4	2.0	2834	0.5	2.2	1858	0.3	1.6	976	0.14	0.07
Female (p=0.0000)	2.4	4.7	2450	2.5	4.8	1602	2.2	4.5	848	0.26	0.21
All children (10-17 years)	0.9	2.8	1684	0.9	2.9	1093	0.8	2.6	591	0.15	0.33
All adults (18 years and above)	1.6	4.0	3600	1.6	4.1	2367	1.4	3.7	1233	0.21	0.13
Child care or cleaning - All household members	2.9	8.5	5284	3.0	8.3	3460	2.9	8.9	1824	0.13	0.64
Male	1.3	4.0	2834	1.3	3.9	1858	1.2	4.3	976	0.10	0.59
Female (p=0.0000)	4.9	11.4	2450	5.0	11.1	1602	4.8	12.0	848	0.18	0.73
All children (10-17 years)	1.9	5.4	1684	2.1	5.5	1093	1.5	5.1	591	0.62	0.03
All adults (18 years and above)	3.5	9.6	3600	3.4	9.3	2367	3.5	10.2	1233	-0.12	0.74

Table 5.9.1: Household Members' Time Use (in hours) Indicators: Balance between Treatment and Control Groups at Baseline (continued)

	Full Sample			Treatment			Control			Diff T-C	p-value
	Mean	SD	N	Mean	SD		Mean	SD	N		
Agriculture/Livestock/Fisheries (past 7 days)											
Agriculture, agricultural processing, livestock/poultry rearing and fishing activities - All household members	0.6	4.9	5284	0.6	5.1	3460	0.4	4.6	1824	0.16	0.35
Male	0.7	5.4	2834	0.7	5.5	1858	0.6	5.3	976	0.05	0.83
Female (p=0.0498)	0.4	4.3	2450	0.5	4.5	1602	0.2	3.8	848	0.29	0.10
All children (10-17 years)	0.1	2.3	1684	0.1	1.2	1093	0.2	3.5	591	-0.10	0.51
All adults (18 years and above)	0.8	5.7	3600	0.9	6.0	2367	0.6	5.1	1233	0.27	0.21
Other Activities (past 7 days)											
Non-agricultural, non-livestock or non-fishing household businesses - All household members	3.9	14.1	5284	3.9	14.3	3460	3.8	13.9	1824	0.14	0.76
Male	3.8	14.4	2834	3.8	14.3	1858	3.9	14.5	976	-0.11	0.85
Female (p=0.9505)	3.9	13.8	2450	4.0	14.2	1602	3.6	13.1	848	0.43	0.46
All children (10-17 years)	0.2	2.0	1684	0.1	1.0	1093	0.3	3.2	591	-0.15	0.28
All adults (18 years and above)	5.6	16.8	3600	5.7	16.9	2367	5.4	16.5	1233	0.21	0.74
Wage, salary, commission or any payment in kind excluding day labor - All household members	4.6	15.2	5284	4.4	14.7	3460	5.0	16.3	1824	-0.60	0.23
Male	5.7	16.8	2834	5.5	16.5	1858	6.1	17.5	976	-0.56	0.43
Female (p=0.0000)	3.4	13.1	2450	3.1	12.2	1602	3.8	14.6	848	-0.66	0.27
All children (10-17 years)	0.1	2.6	1684	0.0	0.6	1093	0.2	4.2	591	-0.22	0.21
All adults (18 years and above)	6.8	18.0	3600	6.5	17.4	2367	7.3	19.1	1233	-0.86	0.22
Casual, part-time or day labor outside the household - All household members	3.8	14.0	5284	3.7	13.9	3460	3.9	14.2	1824	-0.19	0.69
Male	5.0	16.1	2834	4.9	16.1	1858	5.0	16.1	976	-0.09	0.90
Female (p=0.0000)	2.4	11.1	2450	2.4	10.8	1602	2.7	11.6	848	-0.31	0.52
All children (10-17 years)	0.0	0.5	1684	0.0	0.6	1093	0.0	0.0	591	0.02	0.19
All adults (18 years and above)	5.6	16.7	3600	5.4	16.6	2367	5.8	17.0	1233	-0.35	0.61

Table 5.9.2. Primary Cooks' Time Use (in hours) Indicators: Balance between Treatment and Control Groups at Baseline

	Full Sample			Treatment			Control			Diff T-C	p-value
	Mean	SD	N	Mean	SD	N	Mean	SD	N		
Domestic Chores (last 7 days)											
Water collection											
All primary cooks	0.9	2.3	1462	0.9	2.2	963	0.9	2.5	499	-0.02	0.90
Sex of primary cook (p=0.0009)											
Male	1.3	2.6	327	1.3	2.8	217	1.2	2.2	110	0.14	0.62
Female	0.8	2.2	1135	0.8	1.9	746	0.8	2.6	389	-0.07	0.67
Primary Cook Category (p=0.0000)											
Household member	0.7	1.9	958	0.7	1.7	628	0.7	2.2	330	-0.03	0.85
Hired cook	1.3	2.9	504	1.3	2.9	335	1.3	3.0	169	-0.02	0.96
Firewood collection											
All primary cooks	0.0	0.3	1462	0.0	0.2	963	0.0	0.4	499	-0.03	0.14
Sex of primary cook (p=0.5953)											
Male	0.0	0.2	327	0.0	0.2	217	0.0	0.2	110	0.01	0.82
Female	0.0	0.3	1135	0.0	0.2	746	0.1	0.5	389	-0.04	0.11
Primary Cook Category (p=0.0651)											
Household member	0.0	0.3	958	0.0	0.2	628	0.1	0.5	330	-0.05	0.08
Hired cook	0.0	0.1	504	0.0	0.2	335	0.0	0.0	169	0.02	
Production of other fuel materials (uribingo, grass and charcoal)											
All primary cooks	0.3	1.8	1462	0.3	1.6	963	0.4	2.2	499	-0.06	0.62
Sex of primary cook (p=0.3464)											
Male	0.2	0.7	327	0.2	0.7	217	0.3	0.8	110	-0.03	0.75
Female	0.3	2.1	1135	0.3	1.8	746	0.4	2.4	389	-0.06	0.66
Primary Cook Category (p=0.0750)											
Household member	0.3	1.0	958	0.2	0.8	628	0.3	1.3	330	-0.06	0.45
Hired cook	0.4	2.8	504	0.4	2.5	335	0.5	3.3	169	-0.05	0.86

Table 5.9.2. Primary Cooks' Time Use (in hours) Indicators: Balance between Treatment and Control Groups at Baseline (continued)

	Full Sample			Treatment			Control			Diff T-C	p-value
	Mean	SD	N	Mean	SD	N	Mean	SD	N		
Cooking											
All primary cooks	21.7	11.6	1462	21.9	11.9	963	21.4	11.0	499	0.46	0.46
Sex of primary cook (p=0.0132)											
Male	23.1	12.7	327	23.7	13.2	217	22.0	11.7	110	1.74	0.23
Female	21.3	11.3	1135	21.4	11.5	746	21.3	10.9	389	0.09	0.90
Primary Cook Category (p=0.0000)											
Household member	18.9	10.0	958	18.9	10.0	628	18.8	10.0	330	0.06	0.93
Hired cook	27.1	12.6	504	27.5	13.2	335	26.5	11.3	169	1.02	0.36
Child care or cleaning											
All primary cooks	14.1	14.9	1462	14.4	15.5	963	13.4	13.7	499	0.96	0.22
Sex of primary cook (p=0.0507)											
Male	12.6	12.6	327	13.4	13.1	217	11.2	11.6	110	2.13	0.13
Female	14.5	15.5	1135	14.7	16.1	746	14.1	14.2	389	0.64	0.49
Primary Cook Category (p=0.0000)											
Household member	12.6	15.0	958	12.7	15.6	628	12.3	13.8	330	0.45	0.65
Hired cook	16.9	14.4	504	17.5	14.9	335	15.7	13.3	169	1.84	0.16
Agriculture/Livestock/Fisheries (past 7 days)											
Agriculture, agricultural processing, livestock/poultry rearing and fishing activities											
All primary cooks	0.3	2.7	1462	0.3	2.6	963	0.4	2.9	499	-0.07	0.67
Sex of primary cook (p=0.8864)											
Male	0.3	2.7	327	0.4	3.0	217	0.2	2.0	110	0.18	0.51
Female	0.3	2.8	1135	0.3	2.5	746	0.4	3.2	389	-0.14	0.46
Primary Cook Category (p=0.3379)											
Household member	0.4	3.0	958	0.3	2.8	628	0.5	3.3	330	-0.12	0.59
Hired cook	0.2	2.3	504	0.2	2.4	335	0.2	2.0	169	0.04	0.86

Table 5.9.2. Primary Cooks' Time Use (in hours) Indicators: Balance between Treatment and Control Groups at Baseline (continued)

	Full Sample			Treatment			Control			Diff T-C	p-value
	Mean	SD	N	Mean	SD	N	Mean	SD	N		
Other Activities (past 7 days)											
Non-agricultural, non-livestock or non-fishing household businesses											
All primary cooks	3.7	13.3	1462	3.9	13.5	963	3.4	12.8	499	0.53	0.46
Sex of primary cook (p=0.0015)											
Male	1.7	9.0	327	1.9	9.7	217	1.3	7.6	110	0.61	0.53
Female	4.3	14.2	1135	4.5	14.4	746	4.0	13.9	389	0.52	0.55
Primary Cook Category (p=0.0000)											
Household member	5.3	15.9	958	5.6	16.1	628	4.8	15.5	330	0.86	0.42
Hired cook	0.7	4.1	504	0.7	4.7	335	0.6	2.5	169	0.03	0.93
Wage, salary, commission or any payment in kind excluding day labor											
All primary cooks	2.9	12.1	1462	3.0	12.4	963	2.9	11.6	499	0.13	0.84
Sex of primary cook (p=0.0076)											
Male	4.5	14.8	327	4.7	14.7	217	4.1	15.1	110	0.56	0.75
Female	2.5	11.2	1135	2.5	11.5	746	2.5	10.4	389	-0.01	0.99
Primary Cook Category (p=0.9084)											
Household member	3.0	12.2	958	3.3	12.9	628	2.3	10.6	330	0.98	0.21
Hired cook	2.9	12.0	504	2.4	11.2	335	3.9	13.4	169	-1.51	0.21
Casual, part-time or day labor outside the household											
All primary cooks	2.2	10.3	1462	2.2	9.7	963	2.3	11.3	499	-0.12	0.84
Sex of primary cook (p=0.0435)											
Male	3.3	13.6	327	2.3	10.2	217	5.2	18.5	110	-2.86	0.13
Female	2.0	9.1	1135	2.2	9.6	746	1.5	8.0	389	0.65	0.23
Primary Cook Category (p=0.0000)											
Household member	3.3	12.3	958	3.3	11.6	628	3.4	13.6	330	-0.15	0.87
Hired cook	0.2	3.6	504	0.2	3.8	335	0.2	3.1	169	0.00	1.00

Other Activities

As expected, children spend no time in part time or day labor outside the household, and very little time in non-agricultural activity (0.2 hours) and salaried jobs (0.1 hours), compared to their time spent in domestic chores. Children in the 14-17 year age group spent 0.3 hours in non-agricultural activities and teenagers between 14-15 years mainly spent time in salaried jobs (0.2 hours).

Adults in the age groups 35-44 and 45-54 years spent maximum time in non-agricultural, non-livestock or non-fishing household businesses (11.6 and 10.9 hours, respectively), and part-time or day labor outside the household (10.2 hours and 10.3 hours, respectively). Adults in the 55-64 and 25-34 year age groups also spent considerable time in these activities (7.5 hours and 5.4 hours, respectively for the former, and 6 hours and 6.8 hours, respectively for the latter). Most of the older (65 years and above) adults' time (3 hours) was spent in non-agricultural activities and casual or part-time labor. Young adults (18-24 years), on average, spent 1.2 hours in non-agricultural activities and day labor. Among those in wage labor or salaried jobs, adults in the 45-54 years and 25-34 years age groups spent maximum time (11.8 hours and 10.1 hours, respectively), followed by those aged 35-44 years (9.4 hours) and 55-64 years (9 hours). Younger (18-24 years) and older (65 years and above) adults spent less time (at least 1.5 hours) in wage labor.

Adult men spent significantly more time in salaried jobs and casual or part-time labor (8 hours and 6.9 hours, respectively) compared to adult women (5.2 hours and 3.8 hours, respectively) (p=0.00). There were no significant differences between the treatment and control groups on any of the other activities among all adult household members.

5.9.2 Time Use of Primary Cooks

Similar to other household members, primary cooks were also asked about the various activities they engaged in during the past 7 days. As seen in Table YY (page ab), approximately 78% of the primary cooks were female; 65.5% were household members and 34.5% were hired cooks.

Domestic Chores

On average, primary cooks spent 0.9 hours in the past 7 days collecting water, with hired cooks spending significantly (p=0.00) more time in this chore (1.3 hours) compared to household member-primary cooks (0.7 hours). None of the primary cooks' time was spent in firewood collection, although on average, they spent 0.3 hours in fuel material production, with hired cooks spending slightly more time (0.4 hours) in this activity compared to household member-primary cooks (0.3 hours). Male cooks spent significantly (p=0.00) more time in water collection (1.3 hours) compared to female cooks (0.8 hours).

On average, in the last 7 days, primary cooks spent 21.7 hours cooking, with male cooks spending significantly (p=0.01) more time (23.1 hours) compared to female cooks (21.3 hours). Hired cooks spent significantly (p=0.00) more time cooking (27.1 hours) compared to primary cooks who were household members (18.9 hours). Hired cooks also spent significantly (p=0.00) more number of hours in childcare and cleaning activities (16.9 hours) compared to household member primary cooks (12.6 hours). As we would expect, female cooks spent significantly (p=0.00) more time (14.5 hours) compared to their male counterparts (12.6 hours) on this activity.

There are no statistically significant differences between treatment and control groups on any of these domestic chores performed by primary cooks.

Agriculture/Livestock/Fisheries

On average primary cooks spent 0.3 hours in agriculture and related activities. Household member primary cooks spent more time (0.4 hours) in this activity compared to hired cooks (0.2 hours). There are no statistically significant differences between male and female primary cooks and between treatment and control groups in this activity.

Other Activities

On average, primary cooks spent 3.7 hours in non-agricultural activities, with primary cooks that were household members spending significantly (p=0.00) more time (5.3 hours) compared to hired primary cooks (0.7 hours). Female primary cooks spent significantly (p=0.00) more time on this activity (4.3 hours) compared to male primary cooks (1.7 hours).

Primary cooks on average spent 2.9 hours in wage labor and 2.2 hours in casual or part-time labor outside the household. On these activities, male primary cooks spent significantly more time (4.5 hours and 3.3 hours, respectively) compared to female primary cooks (2.5 hours and 2 hours, respectively) (p=0.00 and p=0.04, respectively). Though there are no significant differences between household member-primary cooks and hired cooks in the time spent in wage labor, there are significant differences in the time spent in day labor (3.3 hours and 0.2 hours, respectively) (p=0.00).

There were no statistically significant differences between the treatment and control groups in the time spent by primary cooks in any of these three activities.

5.9 Preferences of main respondents and primary cooks

We collected data on time preferences of main respondents and primary cooks by presenting them with hypothetical scenarios of whether they would like to receive a certain hypothetical amount of money today, or a higher amount in a month's time. We also measured risk-aversion by asking if they would rather take RWF10,000 for certain or play a game with a 50% chance of winning more than RWF10,000 and a 50% chance of winning less than RWF10,000 (see below for details). In the sections below, we present results from this component of our survey.

5.9.1 Money today or a month later[1]

We presented respondents with a hypothetical inter-temporal choice task where they had the option of taking RWF20,000 today or waiting 30 days and receiving a different amount. The future amount was varied to understand time-discounting of respondents, that is, the weight they placed on money today versus money in the future. Approximately 94% main respondents (N=1462) and main respondent-primary cooks (N=775), and 89% non-main respondent-primary cooks (N=686) reported preferring 20K today than 20K in a month. A similar percentage of main respondents and main respondent-primary cooks preferred 20K today than 50K in a month, and 20K today than 40K in a month (32.2% and 37.2% for main respondents; 33.2% and 38.6% for main respondent-primary cooks). Eighty percent main respondents and main-respondent primary cooks reported preference for 20K today over 40K in a month. On varying amounts that could be received in a month, we find that main respondents and main respondent-primary cooks exhibit similar patterns of preferences (see Table XX).

[1] All amounts are in Rwandan Franc (RWF).

Figure 5.9.1 shows the proportion who will wait 30 days for each future amount, among all main respondents. Only 6% would wait for the same future amount as the present amount, and the percent willing to wait increases steadily as the future amount increases, with a noticeable jump between RWF30,000 and RWF40,000. The relatively low percentage of people who would wait for RWF20,000, and the steady increase in the propensity to wait as future values increase, indicates that respondents understood the question.

A key feature of the instrument is that the future values were not asked in ascending order but rather asked randomly, thus enabling us to see whether there were any inconsistent responses. Inconsistency would exist if a respondent stated they would wait for say RWF 25,000 but then NOT wait for RWF40,000. By randomly ordering the future values we can directly estimate the proportion of 'double-switches' in the data. Only 3.6% of cases were double-switches, which is better than reports from laboratory settings among much more literate and numerate respondents (e.g. college students), further suggesting that the choice task was well understood by respondents, and alleviating concerns of hypothetical bias.

Figure 5.9.1: Percent of main respondents willing to wait 30 days for each hypothetical future amount

Twenty-eight percent non-main respondent primary cooks preferred 20K today over 80K in a month; 43.3% preferred 20K today than 30K in a month, 33.7% preferred 20K today over 45K in a month; 56.7% preferred 20K today over 25K in a month; 39.4% preferred 20K today over 35K in a month; and 35.1% preferred 20K today over 40K in a month.

5.9.2 Lottery or 10K for certain

As the take-up of a new technology involves risk, capturing risk-preference is important for analysis of adoption. Similar to the hypothetical inter-temporal choice task, we told respondents to suppose that they could either get RWF10,000 for certain, or engage in a coin toss with the outcomes described below. What would they choose? The expected value of the coin toss game ranged from RWF10,000 to RWF30,000. In two cases losing the coin toss still entailed winning some money (options c and e) to understand whether loss-aversion played a role in attitudes towards risk.

A.	**20,000 (50%)**	**or**	**0 (50%)**
B.	**60,000 (50%)**	**or**	**0 (50%)**
C.	**30,000 (50%)**	**or**	**2,000 (50%)**

D. 30,000 (50%) or 0 (50%)
E. 20,000 (50%) or 2,000 (50%)

Twenty-eight percent main respondents and 27.6% main respondent-primary cooks preferred a lottery (50% chance of receiving 20K or 50% chance of receiving no money) over receiving 10K for certain. A higher percentage of main respondents (43.3%) and main respondent-primary cooks (41.7%) preferred the second lottery wherein there is a 50% chance of winning 60K and a 50% chance of winning no money. The preference for the third lottery (50% chance of winning 30K and a 50% chance of winning 2K) were lower than the second (38.9% for main respondents and 37% for main respondent-primary cooks). Preferences for the fourth (50% chance of winning 30K and a 50% chance of winning no money) and fifth lotteries (50% chance of winning 20K and a 50% chance of winning 2K) were similar for both main respondents (~32%) and main respondent-primary cooks (~31%).

Table lists the lotteries in order of expected value (lowest to highest) and the associated percent of respondents who would play the coin toss among main respondents. The percent of respondents who would play the coin toss increases as the expected value increases but even for highest expected value game only had 43 percent of respondents willing to play. There is some evidence of loss-aversion in the study sample. Game two and three have very different expected values (RWF11,000 versus RWF15,000) yet very similar positive responses. Similarly, games three and four have virtually identical expected values, but game four has a much higher positive take-up where the chance of winning something is guaranteed.

Lottery			Percent who would play
20,000 (50%)	**or**	**0 (50%)**	28
20,000 (50%)	**or**	**2,000 (50%)**	32
30,000 (50%)	**or**	**0 (50%)**	33
30,000 (50%)	**or**	**2,000 (50%)**	39
60,000 (50%)	**or**	**0 (50%)**	43

Twenty percent non-main respondent-primary cooks preferred a lottery (50% chance of receiving 10K or 50% chance of receiving 1K) over receiving 10K for certain. Almost double that percentage (47.4%) preferred the second lottery (50% chance of winning 90K and a 50% chance of winning no money). Non-main respondent-primary cooks' preference for the third lottery (50% chance of winning 50K and a 50% chance of winning 1K) lowered to 44.8% and for the fourth (50% chance of winning 20K and a 50% chance of winning 1K) to even further (32.9%). Preferences for the last lottery (50% chance of winning 35K and a 50% chance of winning 1K) increased to 39.9%.

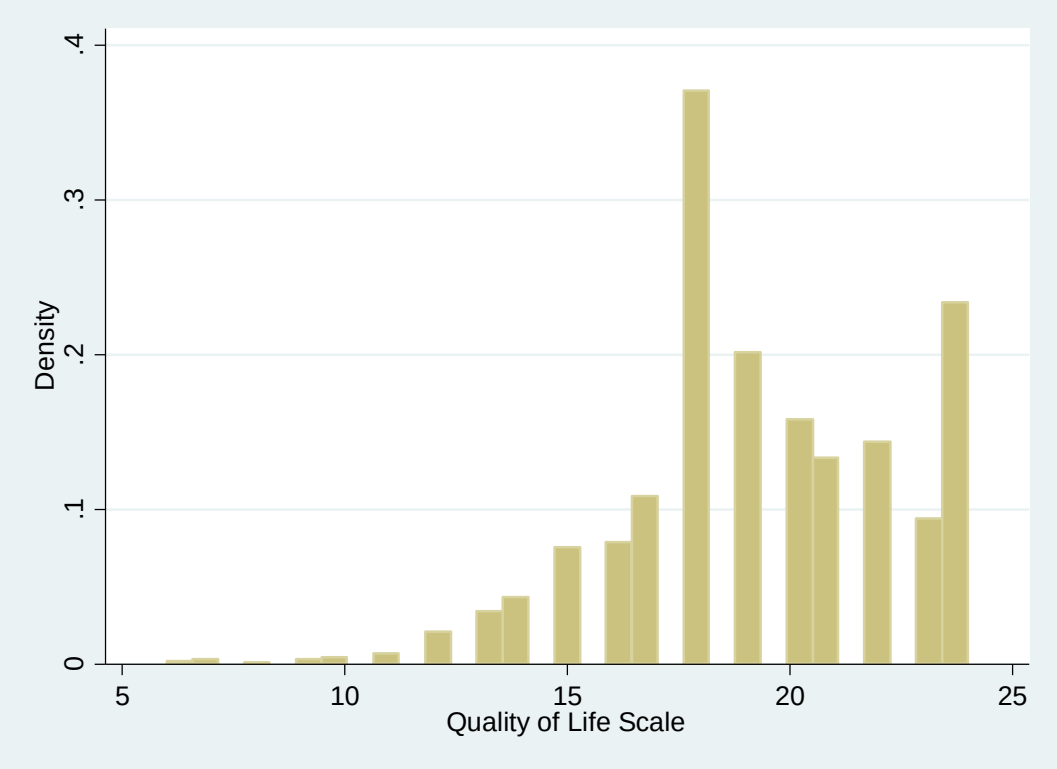
We also asked main respondents and primary cooks their agreement or disagreement with various statements reflective of their subjective well-being. Their responses are reported in the following section.

5.9.3 Subjective well-being

Over 50% of the main respondents agreed with the following statements: (a) 'I enjoy my life' (54.1%); (b) 'I experience positive feelings in my life' (53.4%); (c) 'I am satisfied with my health' (51.8%); (d) 'I am satisfied with my life' (52.6%); (e) 'I generally feel happy' (54.1%); (f) 'I feel positive about the environment' (47.6%); (g) 'I am able to control the important things in my life' (60.5%); (h) 'I feel confident about my ability to handle my personal problems' (50%). More than 55% main respondents strongly agreed with the statement that they felt positive about their future, while 48.9% main respondents reported often feeling nervous and stressed.

Figure 5.9.2 shows the distribution of a 'quality of life' scale generated by adding scores on each of the six quality of life items, and thus ranges from a minimum of 6 to a maximum of 24. The median score is 19 and the 25th percentile is 18, so virtually everyone in the sample is reporting a value of 3 (agree) to the items in the scale. The Cronbach alpha score is 0.86 suggesting a high level of inter-item covariation.

Figure 5.9.2: Distribution of the quality of life scores



More main respondents thought their life would be better in 5 years (87.5%) than those that reported their life getting better in a year (79.2%). On average, main respondents knew more people they could borrow 7K RWF from (4.3) than 70K RWF (2.4).

The patterns of agreement or disagreement with each of the aforementioned statements among main respondent-primary cooks were similar to those of the main respondents reported above (see Table YY). In the following paragraph, we report the results for the non-main respondent-primary cooks.

Over 55% of these primary cooks agreed with the following statements: (a) 'I enjoy my life' (61.2%); (b) 'I experience positive feelings in my life' (56.6%); (c) 'I am satisfied with my health' (59.8%); (d) 'I am satisfied with my life' (61.7%); (e) 'I generally feel happy' (61.7%); (f) 'I feel positive about the environment' (59.5%); and (g) 'I am able to control the important things in my life' (63.6%). While 49.3% non-main respondent primary cooks agreed with feeling positive about their future, and 43% agreed with feeling confident about their ability to handle their personal problems, 42.3% disagreed that they were often nervous and stressed. More primary cooks in this category main respondents thought their life would be better in 5 years (89.4%) than those that reported their life getting better in a year (75.8%). Similar to main respondents and main respondent-primary cooks, on average, non-main respondent primary cooks knew more people they could borrow 7K RWF from (2.1) than 70K RWF (1.2), although these numbers are lower than those for either main respondents or main respondent-primary cooks.

5.10 Social Capital

5.10.1 Social Networks

In this section, we compare the social networks of main respondents, primary cooks who are also main respondents, and other primary cooks. We first look at whether the person of interest knows medical and education professionals, since these professions carry a social prestige, and information shared by these professionals is likely to influence households' decision-making. We then ask respondents about other types of higher SES acquaintances, such as government employees and managers, for similar reasons. Finally, we explore whether the respondents know any stove company representatives, as prior familiarity with them may affect adoption of the new household energy system.

In the total sample of 1462 main respondents, 70% have acquaintances and relatives who are medical professionals, 65.6% education professionals, and only 11.2% report knowing any stove company representative (Table 5.10.1). Comparatively, primary cooks who are also main respondents report knowing a smaller percentage of acquaintances and relatives who are doctors (61.4%), teachers (58.6%), or who work as stove company officials (7.4%). On the other hand, primary cooks that are not main respondents (i.e. are either household members or hired cooks) know even fewer socially influential people: 31.2% know professionals in the health field, 39.4% are acquainted with people in the education sector and 5% know ICS company representatives.

At least 44% of the main respondents and primary cooks (both groups) have female acquaintances and relatives in the medical profession; a majority of their acquaintances and relatives are doctors (64.6%, 58.6% and 57.9%, respectively) and nurses (32.5%, 37% and 36.9%, respectively); and at least 43% of their relatives in this profession belong to the larger extended family but not the household.

Main respondents and primary cooks have a similar proportion of male relatives in the teaching profession (~60%), majority of the relatives (93%) are either teachers or principals, and at least 42% belong to the family.

Main respondents and primary cooks that are also main respondents have almost twice as many relatives in the government service (55.1% and 47.7%, respectively) compared to primary cooks that either household members or hired cooks (21.9%). Most of these relatives for both groups are male (at least 72%), at officer-level positions (~74%) and the rest, at clerical and lower positions. Non-main respondent primary cooks have more extended family relatives in the government service (51.3%) compared to main respondent-primary cooks (45.4%) and the full sample of main respondents (48.1%).

The small percentage of main respondents' and primary cooks' stove representative acquaintances are mostly male (~62%). While the full sample of main respondents and main respondent-primary cooks knew more acquaintances in managerial positions (47.2% and 56/1%, respectively), non-main respondent primary cooks knew more acquaintances that were neither managers nor sales representatives in an improved stove company (38.2%). At least 30% of main respondents' and primary cooks' stove company representatives belong to the family.

On examining differences between treatment and control group households' characteristics, we find that main respondents in the treatment group have a significantly higher percentage of relatives as government clerks (18.5%) compared to those in the control group (11.7%, but significantly lower percentage of male relatives working for an improved stove company (55.4% vs. 80.4% in the control group). There is a significant difference between treatment and control groups in the percentage of non-main respondent primary cooks' relatives in the medical profession belonging to the 'other' category (0% vs. 5.9%). Main respondent-primary cooks in the control group have significantly higher male stove company

acquaintances (91.3%) and relatives in managerial positions in these companies (73.9%) compared to the treatment group (47.1% and 44.1%, respectively). Contrarily, main respondent-primary cooks in the treatment group know significantly more acquaintances who are improved stoves company sales representatives (41.2%) compared to the control group (13%).

Table 5.10.1: Social networks of main respondents and primary cooks

	Main Respondents								Primary Cooks that are also Main Respondents								Primary Cooks that are Not Main Respondents							
	Full Sample		Treatment		Control		Diff T-C	p-value	Full Sample		Treatment		Control		Diff T-C	p-value	Full Sample		Treatment		Control		Diff T-C	p-value
	%	N	%	N	%	N			%	N	%	N	%	N			%	N	%	N	%	N		
Any acquaintances and relatives who are doctors	70.0	1462	70.3	963	69.5	499	0.01	0.76	61.4	775	61.9	506	60.6	269	0.01	0.73	31.2	687	31.9	457	29.6	230	0.02	0.52
Occupation of acquaintances who are doctors																								
Doctors	64.6	1024	64.5	677	64.8	347	0.00	0.93	58.6	476	58.5	313	58.9	163	0.00	0.93	57.9	214	58.9	146	55.9	68	0.03	0.68
Nurses	32.5	1024	32.8	677	31.7	347	0.01	0.72	37.0	476	36.7	313	37.4	163	-0.01	0.88	36.9	214	38.4	146	33.8	68	0.05	0.52
Technicians	1.9	1024	1.8	677	2.0	347	0.00	0.79	2.9	476	3.2	313	2.5	163	0.01	0.64	3.3	214	2.7	146	4.4	68	-0.02	0.56
Other	1.1	1024	0.9	677	1.4	347	-0.01	0.45	1.5	476	1.6	313	1.2	163	0.00	0.74	1.9	214	0.0	146	5.9	68	-0.06	0.04
Male acquaintances and relatives-doctors	55.9	1024	55.4	677	57.1	347	-0.02	0.61	48.5	476	48.6	313	48.5	163	0.00	0.98	49.5	214	46.6	146	55.9	68	-0.09	0.21
Acquaintances (doctors) belong to family, not household	47.8	1024	47.3	677	48.7	347	-0.01	0.66	42.6	476	40.9	313	46	163	-0.05	0.29	50.0	214	51.4	146	47.1	68	0.04	0.56
Any acquaintances and relatives who are teachers	65.6	1462	65.5	963	65.9	499	0.00	0.88	58.5	775	57.3	506	60.6	269	-0.03	0.38	39.4	687	41.8	457	34.3	230	0.07	0.06
Occupation of acquaintances who are teachers																								
Teachers/Principal	93.1	960	92.7	631	93.9	329	-0.01	0.47	93.6	453	92.8	290	95.1	163	-0.02	0.31	93.0	270	92.7	191	93.7	79	-0.01	0.76
Clerk	5.8	960	6.2	631	5.2	329	0.01	0.51	4.9	453	5.5	290	3.7	163	0.02	0.36	7.0	270	7.3	191	6.3	79	0.01	0.76
Other lower	1.0	960	1.1	631	0.9	329	0.00	0.77	1.5	453	1.7	290	1.2	163	0.01	0.67								
Male acquaintances and relatives-teachers	65.2	960	64.8	631	66.0	329	-0.01	0.72	60.3	453	59.3	290	62	163	-0.03	0.58	65.6	270	62.8	191	72.2	79	-0.09	0.13
Acquaintances (teachers) belong to family, not household	44.5	960	43.9	631	45.9	329	-0.02	0.56	42.4	453	39.3	290	47.9	163	-0.09	0.08	46.7	270	48.7	191	41.8	79	0.07	0.30
Any acquaintances and relatives who are in govt. service	55.1	1462	54.4	963	56.5	499	-0.02	0.44	47.7	775	45.7	506	51.7	269	-0.06	0.11	21.9	687	23.4	457	18.7	230	0.05	0.15

	Main Respondents								Primary Cooks that are also Main Respondents								Primary Cooks that are Not Main Respondents							
	Full Sample		Treatment		Control		Diff T-C	p-value	Full Sample		Treatment		Control		Diff T-C	p-value	Full Sample		Treatment		Control		Diff T-C	p-value
	%	N	%	N	%	N			%	N	%	N	%	N			%	N	%	N	%	N		
Occupation of acquaintances who are in govt. service																								
Officer and above	74.5	806	73.1	524	77.3	282	-0.04	0.18	73.5	370	73.2	231	74.1	139	-0.01	0.84	76.0	150	75.7	107	76.7	43	-0.01	0.89
Clerk	16.1	806	18.5	524	11.7	282	0.07	0.01	15.7	370	16.9	231	13.7	139	0.03	0.40	11.3	150	13.1	107	7	43	0.06	0.23
Other lower	9.3	806	8.4	524	11.0	282	-0.03	0.24	10.8	370	10.0	231	12.2	139	-0.02	0.51	12.7	150	11.2	107	16.3	43	-0.05	0.43
Male acquaintances and relatives-in govt. service	72.5	806	72.7	524	72.3	282	0.00	0.91	71.9	370	69.7	231	75.5	139	-0.06	0.22	78.0	150	76.6	107	81.4	43	-0.05	0.51
Acquaintances (govt. service) belong to family, not household	48.1	806	47.1	524	49.6	282	-0.03	0.50	45.4	370	42.4	231	50.4	139	-0.08	0.14	51.3	150	53.3	107	46.5	43	0.07	0.46
Any acquaintances and relatives who work for an improved stove company	11.2	1462	11.6	963	10.2	499	0.01	0.41	7.4	775	6.7	506	8.6	269	-0.02	0.37	5.0	687	4.4	457	6.1	230	-0.02	0.35
Occupation of acquaintances who work for an improved stove company																								
Management	47.2	163	42	112	58.8	51	-0.17	0.05	56.1	57	44.1	34	73.9	23	-0.30	0.02	32.4	34	40.0	20	21.4	14	0.19	0.25
Sales rep	38.0	163	41.1	112	31.4	51	0.10	0.23	29.8	57	41.2	34	13	23	0.28	0.01	29.4	34	30.0	20	28.6	14	0.01	0.93
Other	14.7	163	17	112	9.8	51	0.07	0.19	14.0	57	14.7	34	13	23	0.02	0.86	38.2	34	30.0	20	50	14	-0.20	0.25
Male acquaintances and relatives-working for an improved stove company	63.2	163	55.4	112	80.4	51	-0.25	0.00	64.9	57	47.1	34	91.3	23	-0.44	0.00	61.8	34	65.0	20	57.1	14	0.08	0.65
Acquaintances (improved stove company) belong to family, not household	31.9	163	28.6	112	39.2	51	-0.11	0.19	33.3	57	26.5	34	43.5	23	-0.17	0.19	29.4	34	40.0	20	14.3	14	0.26	0.09

5.10.2 Individual Leadership and Community Influence

On the three statements regarding comfort speaking up in public, (a) to help decide on infrastructure to be built in the community, (b) to ensure proper payment of wages for public works or other similar programs, (c) about things that are important to me, more than half the respondents (between 50%-61%) agree with each of the three statements. While there is strong agreement among main respondent-primary cooks for these three statements (between 24%-29%), similar levels of *dis*agreement are seen among non-main respondent primary cooks (25%-29%). These differences in percentages may be indicative of varying levels of leadership and community influence between the two groups of primary cooks.

Main respondents in the treatment group have significantly higher levels of agreement regarding comfort speaking up in public (a) about things that are important to them and (b) to ensure proper payment of wages for public works or similar programs, compared to those in the control group.

Table 5.10.2: Individual leadership and community influence of main respondents and primary cooks

	Full Sample		Treatment		Control		Diff T-C	p-value
	%	N	%	N	%	N		
Main Respondents								
Feel comfortable speaking up in public to help decide on infrastructure to be built in my community								
Strongly disagree	2.9	1462	3.3	963	2.2	499	0.01	0.20
Disagree	11.6	1462	11.3	963	12.2	499	-0.01	0.61
Agree	55.9	1462	57.4	963	52.9	499	0.05	0.10
Strongly agree	29.5	1462	27.9	963	32.7	499	-0.05	0.06
Feel comfortable speaking up in public to ensure proper payment of wages for public works or other similar programs								
Strongly disagree	3.1	1462	3.4	963	2.6	499	0.01	0.37
Disagree	12.7	1462	12.4	963	13.2	499	-0.01	0.64
Agree	54.5	1462	55.6	963	52.3	499	0.03	0.24
Strongly agree	29.7	1462	28.7	963	31.9	499	-0.03	0.21
Feel comfortable speaking up in public about things that are important to me								
Strongly disagree	3.4	1462	3	963	4.0	499	-0.01	0.34
Disagree	10.3	1462	10.2	963	10.4	499	0.00	0.88
Agree	50.9	1462	53.1	963	46.5	499	0.07	0.02
Strongly agree	35.5	1462	33.7	963	39.1	499	-0.05	0.05
Primary Cooks that are also Main Respondents								
Feel comfortable speaking up in public to help decide on infrastructure to be built in my community								
Strongly disagree	2.8	775	2.8	506	3	269	0.00	0.87
Disagree	12.6	775	12.6	506	12.6	269	0.00	1.00
Agree	60.9	775	61.5	506	59.9	269	0.02	0.66
Strongly agree	23.6	775	23.1	506	24.5	269	-0.01	0.66
Feel comfortable speaking up in public to ensure proper payment of wages for public works or other similar programs								
Strongly disagree	3.5	775	3.4	506	3.7	269	0.00	0.80
Disagree	14.1	775	12.8	506	16.4	269	-0.04	0.19
Agree	58.3	775	59.7	506	55.8	269	0.04	0.29

Strongly agree	24.1	775	24.1	506	24.2	269	0.00	0.99
Feel comfortable speaking up in public about things that are important to me								
Strongly disagree	3.2	775	2.0	506	5.6	269	-0.04	0.02
Disagree	11.9	775	11.3	506	13	269	-0.02	0.48
Agree	55.9	775	59.1	506	49.8	269	0.09	0.01
Strongly agree	29.0	775	27.7	506	31.6	269	-0.04	0.26
Primary Cooks that are Not Main Respondents								
Feel comfortable speaking up in public to help decide on infrastructure to be built in my community								
Strongly disagree	9.5	687	9.2	457	10.4	230	-0.01	0.61
Disagree	27.3	687	26.0	457	29.6	230	-0.04	0.33
Agree	52.5	687	53.8	457	49.6	230	0.04	0.29
Strongly agree	10.8	687	10.9	457	10.4	230	0.01	0.84
Feel comfortable speaking up in public to ensure proper payment of wages for public works or other similar programs								
Strongly disagree	9.2	687	9.2	457	9.6	230	0.00	0.87
Disagree	28.7	687	26.3	457	33.5	230	-0.07	0.05
Agree	49.6	687	52.3	457	43.9	230	0.08	0.04
Strongly agree	12.5	687	12.3	457	13	230	-0.01	0.77
Feel comfortable speaking up in public about things that are important to me								
Strongly disagree	5.0	687	3.7	457	7.4	230	-0.04	0.06
Disagree	25.1	687	25.4	457	24.3	230	0.01	0.77
Agree	54.1	687	55.8	457	50.9	230	0.05	0.22
Strongly agree	15.9	687	15.1	457	17.4	230	-0.02	0.45

5.10.3 Group Membership

While most common groups present in the community reported by main respondents and primary cooks are similar, their awareness of these groups' existence differs. Religious groups are most common (41.3% for main respondents, 43.6% for main respondent-primary cooks, 22.9% for non-main respondent-primary cooks), followed by microfinance groups (35.9% for main respondents, 34.8% for main respondent-primary cooks, 15.6% for non-main respondent-primary cooks), trade or business associations (20.4% for main respondents, 20.8% for main respondent-primary cooks, 10.5% for non-main respondent-primary cooks), civic or charitable groups (21.6% for main respondents, 22.3% for main respondent-primary cooks, 9.6% for non-main respondent-primary cooks) and mutual help or insurance groups (16.6% for main respondents, 17.4% for main respondent-primary cooks, 5.8% for non-main respondent-primary cooks). Community groups such as agriculture and related producer groups and water users' groups, more commonly found in rural areas, are less common in our urban study area (8.4% and 1.9% for main respondents; 4% and 1% for non-main respondent-primary cooks). The community groups that main respondents and primary cooks most actively participate in, mirror their awareness of groups in their residential area. Most main respondents and non-main respondent-primary cooks are active in religious groups (72.3% and 63.1%, respectively), civic or charitable groups (59.2% and 47%, respectively), insurance groups (52.5% and 45%, respectively), microfinance groups (44.1% and 39.3%, respectively) and trade or business associations (33.9% and 30.6%, respectively).

The only significant difference between treatment and control groups in the full sample of main respondents is on household members' active participation in insurance groups. Main respondent-primary cooks in the control group report more participation in other community groups (60%) than those in the treatment group (36.7%). Among non-main respondent-primary cooks, the only significant difference between treatment (33.3%) and control groups (0%) is on household members' active participation in agriculture and other producers' groups.

Table 5.10.3: Group Membership of main respondents and primary cooks

	Full Sample		Treatment		Control		Diff T-C	p-value
	%	N	%	N	%	N		
Main Respondents								
Presence of agricultural/livestock/fisheries producers' group in community	8.4	1462	8.6	963	8.0	499	0.01	0.69
Own/other household member's active participation in agricultural/livestock/fisheries' producers' group in community	27.6	123	25.3	83	32.5	40	-0.07	0.42
Presence of credit/microfinance (tontine/ibimina) group in community	35.9	1462	36.8	963	34.1	499	0.03	0.31
Own/other hh member's active participation in credit/microfinance	44.1	524	42.7	354	47.1	170	-0.04	0.34
Presence of water users' group in community	1.9	1462	1.8	963	2.2	499	0.00	0.58
Own/other hh member's active participation in water users' group	28.6	28	23.5	17	36.4	11	-0.13	0.49
Presence of mutual help/insurance group in community	16.6	1462	16.9	963	15.8	499	0.01	0.59
Own/other hh member's active participation in mutual help/insurance group	52.5	242	47.9	163	62.0	79	-0.14	0.04
Presence of trade/business association group in community	20.4	1462	21	963	19.2	499	0.02	0.43
Own/other hh member's active participation in trade/business association	33.9	298	32.7	202	36.5	96	-0.04	0.52
Presence of civic/charitable group in community	21.6	1462	21.2	963	22.4	499	-0.01	0.58
Own/other hh member's active participation in civic/charitable group	59.2	316	56.4	204	64.3	112	-0.08	0.17
Presence of religious group in community	41.3	1462	42.7	963	38.5	499	0.04	0.12
Own/other hh member's active participation in religious group	72.3	603	71.5	411	74.0	192	-0.02	0.53
Presence of other groups in community	21.0	1462	21.5	963	20.0	499	0.02	0.51
Own/other hh member's active participation in other groups	46.6	307	43.5	207	53.0	100	-0.10	0.12
Primary Cooks that are also Main Respondents								
Presence of agricultural/livestock/fisheries producers' group in community	8.9	775	8.5	506	9.7	269	-0.01	0.59
Own/other hh member's active participation in agricultural/livestock/fisheries' producers' group in community	24.6	69	18.6	43	34.6	26	-0.16	0.16
Presence of credit/microfinance (tontine/ibimina) group in community	34.8	775	35.6	506	33.5	269	0.02	0.56
Own/other household member's active participation in credit/microfinance	36.3	270	32.8	180	43.3	90	-0.11	0.10

	Full Sample		Treatment		Control		Diff T-C	p-value
	%	N	%	N	%	N		
Own/other hh member's active participation in water users' group	31.3	16	30.0	10	33.3	6	-0.03	0.90
Presence of mutual help/insurance group in community	17.4	775	18.8	506	14.9	269	0.04	0.16
Own/other hh member's active participation in mutual help/insurance group	46.7	135	42.1	95	57.5	40	-0.15	0.10
Presence of trade/business association group in community	20.8	775	21.3	506	19.7	269	0.02	0.59
Own/other hh member's active participation in trade/business association	22.4	161	19.4	108	28.3	53	-0.09	0.23
Presence of civic/charitable group in community	22.3	775	21.9	506	23.0	269	-0.01	0.73
Own/other hh member's active participation in civic/charitable group	52.0	173	49.5	111	56.5	62	-0.07	0.38
Presence of religious group in community	43.6	775	44.9	506	41.3	269	0.04	0.34
Own/other hh member's active participation in religious group	70.4	338	69.6	227	72.1	111	-0.03	0.64
Presence of other groups in community	19.7	775	19.4	506	20.4	269	-0.01	0.72
Own/other hh member's active participation in other groups	45.1	153	36.7	98	60	55	-0.23	0.01
Primary Cooks that are Not Main Respondents								
Presence of agricultural/livestock/fisheries producers' group in community	4.1	687	3.9	457	4.3	230	0.00	0.80
Own/other hh member's active participation in agricultural/livestock/fisheries' producers' group in community	21.4	28	33.3	18	0	10	0.33	0.01
Presence of credit/microfinance group in community	15.6	687	14.9	457	17.0	230	-0.02	0.49
Own/other household member's active participation in credit/microfinance	39.3	107	42.6	68	33.3	39	0.09	0.34
Presence of water users' group in community	1.0	687	0.7	457	1.7	230	-0.01	0.25
Own/other hh member's active participation in water users' group	0.0	7	0.0	3	0	4	0.00	
Presence of mutual help/insurance group in community	5.8	687	5.5	457	6.5	230	-0.01	0.59
Own/other hh member's active participation in mutual help/insurance group	45.0	40	44	25	46.7	15	-0.03	0.87
Presence of trade/business association group in community	10.5	687	10.5	457	10.4	230	0.00	0.98
Own/other hh member's active participation in trade/business association	30.6	72	27.1	48	37.5	24	-0.10	0.38
Presence of civic/charitable group in community	9.6	687	9.2	457	10.4	230	-0.01	0.61
Own/other hh member's active participation in civic/charitable group	47.0	66	45.2	42	50.0	24	-0.05	0.71
Presence of religious group in community	22.9	687	22.5	457	23.5	230	-0.01	0.78
Own/other hh member's active participation in religious group	63.1	157	58.3	103	72.2	54	-0.14	0.08
Presence of other groups in community	8.7	687	10.1	457	6.1	230	0.04	0.06
Own/other hh member's active participation in other groups	44.8	58	44.4	45	46.2	13	-0.02	0.91

5.10.4 Trust and Community Cohesion

Community cohesion is important as it shapes neighborhoods and empowers residents. Institutional integration can foster community bonding and trust, which is critical for information sharing and adoption of new interventions, such as an improved household energy system. We ask respondents their levels of agreement or disagreement on seven statements indicative of their trust and cohesion in the neighborhood.

Less than 50% main respondents and non-main respondent-primary cooks agree with statements relating to trust, such as, 'confidence or faith in most people' (41.4% and 45.3%, respectively), and 'can count on my neighbor to send an important letter' (41.6% and 39.5%, respectively). The percentage of respondents that disagree was not that much lower: 37% and 39.3%, respectively for main respondents, and 35.6% and 37.5%, respectively for non-main respondent-primary cooks.

Interestingly, non-main respondent-primary cooks agree more than main respondents on statements related to agency. While 62.2% of the former group agree that their life is determined by their own actions, only 59.1% of the latter agree with that statement. Likewise, for the statement, 'I can take important decisions that can change my life', 65.3% non-main respondent-primary cooks agree, while only 55.2% main respondents agree.

On statements relating to community cohesion as well, non-main respondent-primary cooks agree more than the main respondents on two out of the three statements. More non-main respondent-primary cooks agree that they feel part of the community (64.9% compared to 59% main respondents) and have close friends or relatives they could talk to (56.1% vs. 44.6%). At least 50% of the respondents (54.5% main respondents and 51% non-main respondent-primary cooks) agree with the statement that they have space to participate in decisions in their community.

Among main respondents, significant differences between treatment and control groups in the full sample were on the strong disagreement and agreement of statements: 'Confidence or faith in most people' and 'I can take important decisions that can change my life', respectively. There was also a significant difference between treatment and control groups on the agreement and strong agreement of the statement 'I have space to participate in decisions in my community'.

Main-respondent primary cooks in the two groups significantly differed on the (a) agreement of the statement 'I can count on my neighbor to send an important letter'; and (b) agreement and strong agreement of the statement 'I have space to participate in decisions in my community'. Among non-main respondent-primary cooks, significant differences between treatment and control groups were on the: (a) the strong disagreement of the statement 'I can take important decisions that can change my life'; and (b) the strong disagreement and disagreement of the statement 'I have space to participate in decisions in my community'.

Table 5.10.4: Trust and community cohesion among main respondents and primary cooks

	Full Sample		Treatment		Control		Diff T-C	p-value
	%	N	%	N	%	N		
Main Respondents								
Confidence or faith in most people								
Strongly disagree	7.3	1462	5.8	963	10.2	499	-0.04	0.01
Disagree	37.0	1462	37.1	963	36.7	499	0.00	0.88
Agree	41.4	1462	41.8	963	40.5	499	0.01	0.61
Strongly agree	14.3	1462	15.3	963	12.6	499	0.03	0.16
Can count on my neighbor to send an important letter								

Strongly disagree	11.4	1462	10.9	963	12.4	499	-0.02	0.40
Disagree	39.3	1462	38.2	963	41.3	499	-0.03	0.26
Agree	41.6	1462	43.2	963	38.7	499	0.05	0.10
Strongly agree	7.7	1462	7.7	963	7.6	499	0.00	0.96
My life is determined by my own actions								
Strongly disagree	1.9	1462	1.3	963	3.0	499	-0.02	0.05
Disagree	14.2	1462	14.3	963	14.0	499	0.00	0.88
Agree	59.1	1462	58.6	963	60.1	499	-0.02	0.57
Strongly agree	24.7	1462	25.8	963	22.8	499	0.03	0.22
I can take important decisions that can change my life								
Strongly disagree	1.0	1462	0.9	963	1.2	499	0.00	0.64
Disagree	5.7	1462	4.9	963	7.2	499	-0.02	0.08
Agree	55.2	1462	57.2	963	51.3	499	0.06	0.03
Strongly agree	38.1	1462	37	963	40.3	499	-0.03	0.22
I have space to participate in decisions in my community								
Strongly disagree	3.3	1462	2.7	963	4.4	499	-0.02	0.11
Disagree	14.2	1462	13.9	963	14.6	499	-0.01	0.71
Agree	54.5	1462	57.9	963	47.7	499	0.10	0.00
Strongly agree	28.1	1462	25.4	963	33.3	499	-0.08	0.00
I feel part of the community								
Strongly disagree	0.8	1462	0.6	963	1.0	499	0.00	0.46
Disagree	5.4	1462	5	963	6.2	499	-0.01	0.34
Agree	59.1	1462	60.2	963	56.9	499	0.03	0.22
Strongly agree	34.7	1462	34.2	963	35.9	499	-0.02	0.52
I have close friends or relatives I can talk to								
Strongly disagree	0.4	1462	0.4	963	0.4	499	0.00	0.97
Disagree	2.3	1462	1.9	963	3.2	499	-0.01	0.14
Agree	44.6	1462	45.9	963	42.1	499	0.04	0.16
Strongly agree	52.6	1462	51.8	963	54.3	499	-0.03	0.37
Primary Cooks that are also Main Respondents								
Confidence or faith in most people								
Strongly disagree	7.2	775	5.9	506	9.7	269	-0.04	0.07
Disagree	41.8	775	41.9	506	41.6	269	0.00	0.94
Agree	39.0	775	40.1	506	36.8	269	0.03	0.37
Strongly agree	12.0	775	12.1	506	11.9	269	0.00	0.95
Can count on my neighbor to send an important letter								
Strongly disagree	12.4	775	10.7	506	15.6	269	-0.05	0.06
Disagree	40.9	775	39.3	506	43.9	269	-0.05	0.22
Agree	40.3	775	43.5	506	34.2	269	0.09	0.01
Strongly agree	6.5	775	6.5	506	6.3	269	0.00	0.91
My life is determined by my own actions								
Strongly disagree	1.7	775	1.2	506	2.6	269	-0.01	0.19
Disagree	16.4	775	17.2	506	14.9	269	0.02	0.40
Agree	60.5	775	60.1	506	61.3	269	-0.01	0.73
Strongly agree	21.4	775	21.5	506	21.2	269	0.00	0.91
I can take important decisions that can change my life								
Strongly disagree	1.0	775	1.0	506	1.1	269	0.00	0.87
Disagree	7.4	775	6.5	506	8.9	269	-0.02	0.24
Agree	59.4	775	61.5	506	55.4	269	0.06	0.10

Strongly agree	32.3	775	31.0	506	34.6	269	-0.04	0.32
I have space to participate in decisions in my community								
Strongly disagree	3.2	775	2.4	506	4.8	269	-0.03	0.10
Disagree	17.0	775	17.4	506	16.4	269	0.01	0.71
Agree	57.7	775	60.7	506	52	269	0.09	0.02
Strongly agree	22.1	775	19.6	506	26.8	269	-0.07	0.03
I feel part of the community								
Strongly disagree	0.6	775	0.6	506	0.7	269	0.00	0.81
Disagree	6.1	775	5.1	506	7.8	269	-0.03	0.16
Agree	64.8	775	65.0	506	64.3	269	0.01	0.85
Strongly agree	28.5	775	29.2	506	27.1	269	0.02	0.53
I have close friends or relatives I can talk to								
Strongly disagree	0.4	775	0.4	506	0.4	269	0.00	0.96
Disagree	3.5	775	3.0	506	4.5	269	-0.02	0.31
Agree	49.2	775	50.4	506	46.8	269	0.04	0.35
Strongly agree	47.0	775	46.2	506	48.3	269	-0.02	0.58
Primary Cooks that are Not Main Respondents								
Confidence or faith in most people								
Strongly disagree	6.4	687	5.5	457	8.3	230	-0.03	0.19
Disagree	35.6	687	36.8	457	33.5	230	0.03	0.39
Agree	45.3	687	44.4	457	47	230	-0.03	0.53
Strongly agree	12.7	687	13.3	457	11.3	230	0.02	0.44
Can count on my neighbor to send an important letter								
Strongly disagree	15.2	687	15.5	457	14.8	230	0.01	0.79
Disagree	37.5	687	36.8	457	38.7	230	-0.02	0.62
Agree	39.5	687	39.8	457	38.7	230	0.01	0.78
Strongly agree	7.9	687	7.9	457	7.8	230	0.00	0.98
My life is determined by my own actions								
Strongly disagree	2.9	687	2.0	457	4.8	230	-0.03	0.07
Disagree	20.3	687	20.4	457	20	230	0.00	0.91
Agree	62.2	687	63.5	457	60	230	0.04	0.38
Strongly agree	14.6	687	14.2	457	15.2	230	-0.01	0.73
I can take important decisions that can change my life								
Strongly disagree	1.9	687	0.9	457	3.9	230	-0.03	0.03
Disagree	8.7	687	7.2	457	11.7	230	-0.05	0.07
Agree	65.3	687	68.1	457	60	230	0.08	0.04
Strongly agree	24.1	687	23.9	457	24.3	230	-0.01	0.89
I have space to participate in decisions in my community								
Strongly disagree	8.9	687	6.6	457	13.5	230	-0.07	0.01
Disagree	28.9	687	32.4	457	21.7	230	0.11	0.00
Agree	51.0	687	49.7	457	53.9	230	-0.04	0.29
Strongly agree	11.2	687	11.4	457	10.9	230	0.01	0.84
I feel part of the community								
Strongly disagree	2.8	687	2.6	457	3	230	0.00	0.76
Disagree	12.8	687	13.6	457	11.7	230	0.02	0.49
Agree	64.9	687	64.1	457	66.1	230	-0.02	0.61
Strongly agree	19.5	687	19.7	457	19.1	230	0.01	0.86
I have close friends or relatives I can talk to								
Strongly disagree	2.3	687	2.2	457	2.6	230	0.00	0.74

Disagree	6.7	687	7.7	457	4.8	230	0.03	0.13
Agree	56.1	687	56.5	457	55.7	230	0.01	0.84
Strongly agree	34.8	687	33.7	457	37	230	-0.03	0.40

5.11 Carbon Monoxide Exposure for Main Cook

5.11.1 Overview

Carbon monoxide (CO) is produced during combustion of biofuels and exposure to it at high concentrations over sufficiently long periods is a health concern. In an effort to monitor the main cook's exposure to CO, a CO data logger was worn for a 24-hour monitoring period by the main cook at 1462 households in the HPC study; 28 households refused to participate in the CO monitoring. Valid CO exposure information was collected from 78.7% of the HPC households (N=1150). The remaining CO data files downloaded from the CO data loggers were not usable for various reasons, such as batteries of data loggers dying prior to the end of the 24-hour monitoring periods, or inability to match files from CO data loggers to the database. The data loggers recorded CO concentrations once per minute. A 24-hour average and hourly averages were calculated from each of the 1150 valid data files.

5.11.2 Twenty four-hour average CO exposures

A 24-hour average CO concentration was calculated from each of the valid data files. 24-hour average CO exposures for the cooks ranged from 0 to 138 ppm. The median, average, and standard deviation of the 24-hour average CO exposures for the cooks were 3.2, 6.2, and 9.2 ppm, respectively. Treatment and control groups are compared in Table 5.11.1.

Table 5.11.1: Primary cooks' 24-hour average CO exposure in HPC sample

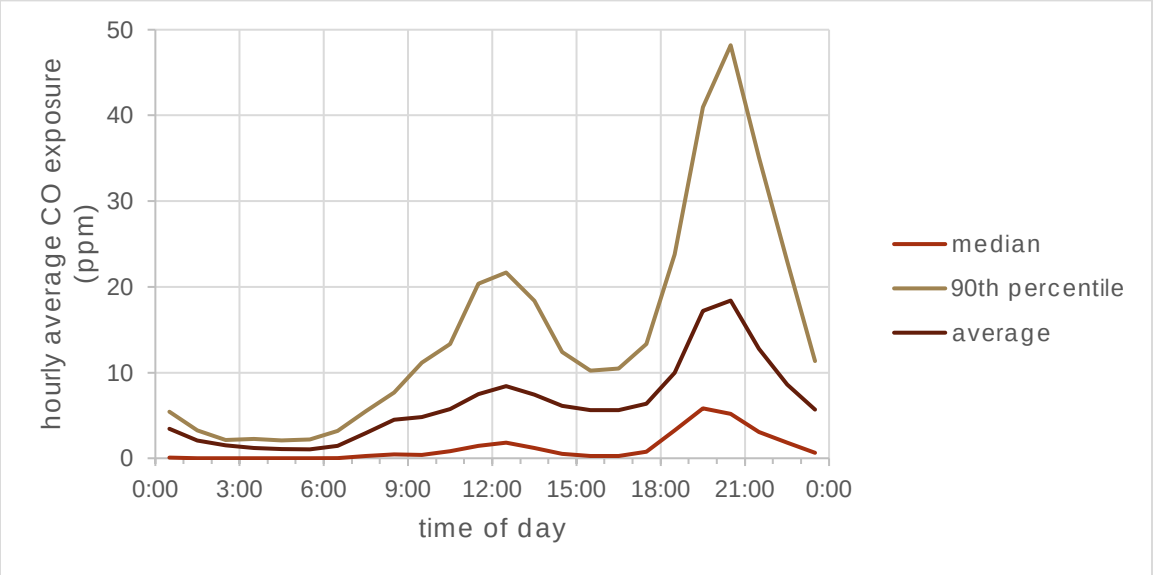
HPC Sample			**Treatment**			**Control**			**Diff T-C (ppm)**	**p-value**
Average (ppm)	SD (ppm)	N	Average (ppm)	SD (ppm)	N	Average (ppm)	SD (ppm)	N		
6.22	9.15	1150	6.17	8.30	750	6.31	10.54	400	-0.14	0.41

5.11.3 One-hour average CO exposures

In addition to a 24-hour average exposure, hourly average CO exposures were calculated for each hour of the day for each cook. Community exposure patterns were determined by compiling hourly averages for all cooks. Hourly average CO exposures for the cooks ranged from 0 to 681 ppm. The median, average, and standard deviation of the hourly average CO exposures for the cooks were 0.5, 6.2, and 21.1 ppm, respectively

Daily temporal hourly average exposure trends across the community are shown in Figure 5.11.1. This figure shows the median, average, and 90th percentile for each hour of the day for hourly average CO exposure across the 1150 cooks. The two main exposure periods are around noon and the early evening.

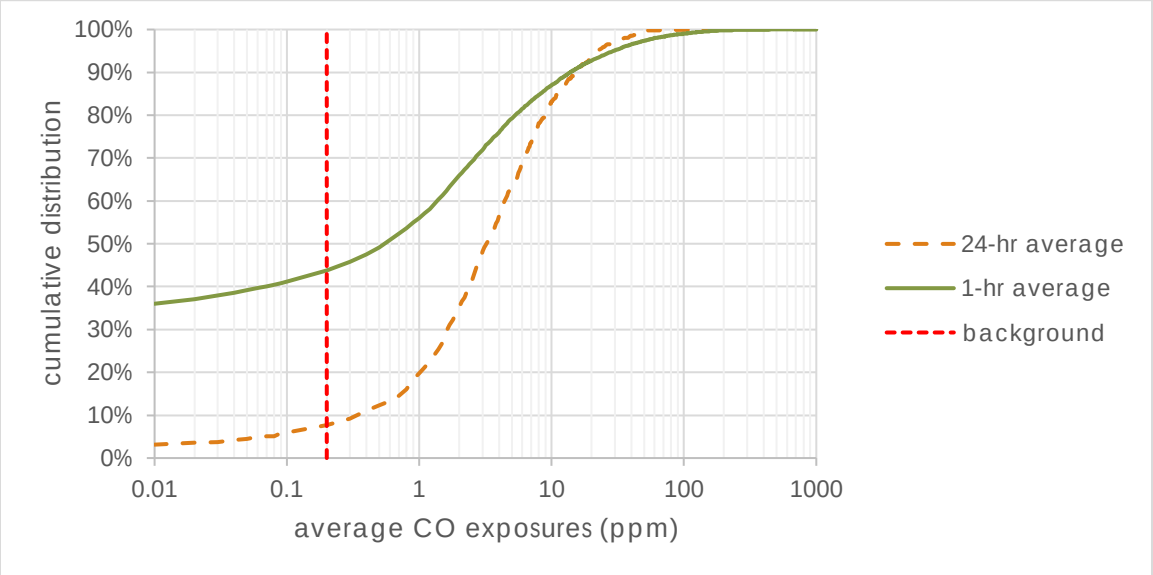
Figure 5.11.1: Median, average, and 90th percentile for each hour of the day for hourly average CO exposure across the 1150 cooks.



5.11.4 Limitations of CO Measurements

Lascar's EasyLog carbon monoxide data loggers (model EL-USB-CO) were used to monitor CO concentrations. These data loggers have a working range from 0 to 1000 ppm, which is sufficient for the purposes of this project. A weakness of these data loggers for this project is their lack of accuracy at low concentrations. Some of the data files from personal exposure monitoring had readings of zero throughout the monitoring period. The background concentration in clean air is approximately 0.2 ppm, which is below the data loggers output interval of 0.5 ppm (i.e., the first possible non-zero reading is 0.5 ppm). It is possible for a data logger to record no exposure because the first possible non-zero reading of 0.5 ppm is greater than the concentration of CO in clean air. However, it is more likely that the "zero" of the monitors vary from one monitor to the next. Ideally, the monitors would record a reading of zero when the concentration is zero. More likely is that some of the data loggers record zero even when the concentration is 1 or 2 ppm. Given this, very low values of 1-hour or 24-hour average concentrations should be viewed with scepticism. For example, Figure 5.11.2 shows cumulative distributions of the 1-hour and 24-hour average concentrations. Note the abundance of values below the background concentration in clean air of 0.2 ppm (i.e., 7.7% of the 24-hour average values and 44% of the 1-hour averages).

Figure 5.11.2: Cumulative distributions for 1-hour and 24-hour average CO exposures.



5.12 Stove Use Patterns

5.12.1 Overview

LabJack Digit-TL temperature data loggers were used to monitor temperatures on or near stoves. Temperature variations can be used as a surrogate of stove use patterns. The processing of the LabJack data files is ongoing.

6. Exposure Monitoring

6.1 Basic Household Descriptors Related to Household Air Pollution

Some of the basic household variables collected in the EM survey that may have an effect on levels of household air pollution and personal exposure include location of cooking, kitchen design (size and ventilation), and types of stoves and fuel. Cooking outdoors should provide greater ventilation than cooking indoors and should lead to lower concentrations of pollutants generated in the cooking area. Of the 180 EM households, 72.8% indicated that they cooked indoors during the seven days prior to the survey, with the remaining 27.2% cooking outdoors. Levels of household air pollution related to combustion may decrease with increasing kitchen size. Of the 128 measured EM kitchens, kitchen area ranged from 1.9 to 189.0 m^2 with a median area of 5.7 m^2. Kitchen volume ranged from 3.6 to 430.9 m^3 with a median volume of 13.3 m^3. Only 2 of the 131 households (1.5%) with an indoor kitchen also had a chimney.

All 180 households designated a most commonly used stove with 63.9% of the households designating a second most commonly used stove. Portable and fixed charcoal stoves accounted for 93.3% and 80.0% of the most and second most commonly used stoves, respectively. Traditional three stone/brick stoves accounted for 3.9% and 6.1% of the most and second most commonly used stoves, respectively. Given the prevalence of charcoal stoves, it is not surprising that 93.3% and 81.7% designated charcoal as the fuel used in the most and second most commonly used stoves, respectively. Single day charcoal use ranged from 0.3 to 12.1 kg with a median use of 2.1 kg (N=155). 5.0% and 6.1% designated fuelwood as the fuel used in the most and second most commonly used stoves, respectively.

6.2 Carbon Monoxide Concentrations

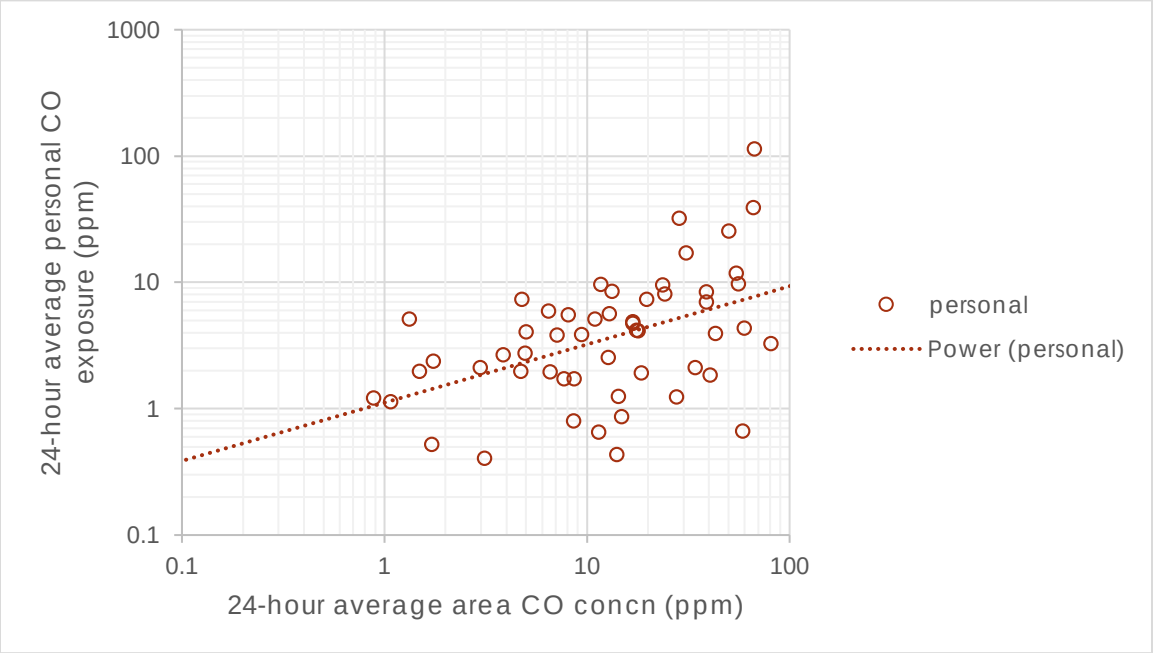
6.2.1 Overview

A carbon monoxide data logger was worn for a 24-hour monitoring period by the main cook at 180 households in the EM part of the study. Data loggers were also deployed near household stoves in 60 of the 180 EM households. As in the HPC CO monitoring effort, there were issues with batteries and the naming of data files that led to a loss of sampling results. There were 162 valid data files from monitoring the CO exposure of the main cooks (i.e., personal samples) and 57 valid data files from monitoring the CO concentration near household stoves (i.e., area samples).

6.2.2 Twenty four-hour Average CO Results

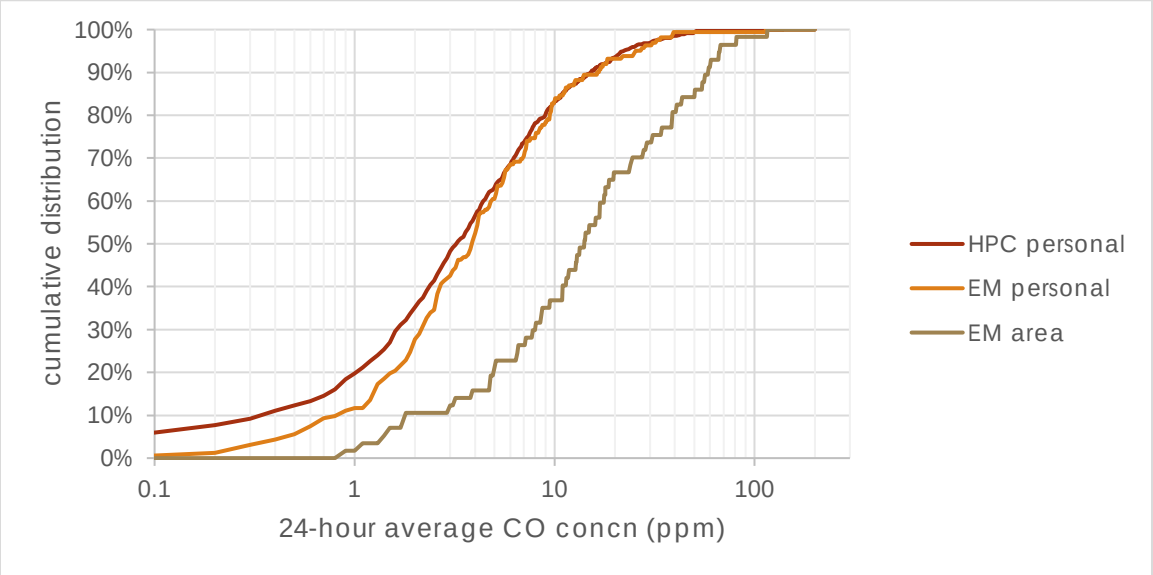
A 24-hour average CO concentration was calculated from each of the valid data files for the personal and area samples. 24-hour average CO exposures for the main cooks (i.e., personal samples) ranged from 0 to 114 ppm. The median, average, and standard deviation of the 162 personal samples were 3.9, 7.0, and 11.2 ppm, respectively. 24-hour average CO concentrations measured near household stoves ranged from 1 to 116 ppm. The median, average, and standard deviation of the 57 area samples were 14.1, 22.7, and 23.4 ppm, respectively. The median personal to area concentration ratio in the 54 households where both personal and area samples were collected was 0.32 (average of 0.52 and standard deviation of 0.62). Figure 6.2.1 shows the relationship between personal and area 24-hour average CO concentrations.

Figure 6.2.1: 24-hour average personal CO exposure as a function of 24-hour average area CO concentration



Each of the main cook's exposure to CO was first measured in the HPC study and, in a subset of households, a second time in the EM study. Figure 6.2.2 compares the cumulative distributions of 24-hour average CO concentrations from the HPC measurements (N=1150), the EM personal measurements (N=162), and the EM area measurements (N=57). The HPC and EM distributions are similar above their median values, but deviate at lower concentrations

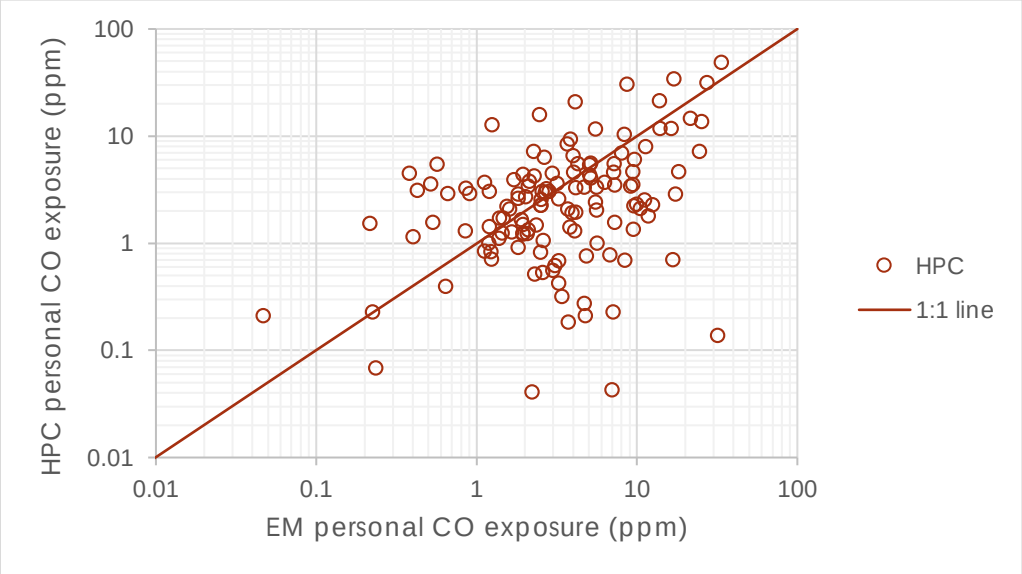
Figure 6.2.2: Cumulative distributions of 24-hour average CO concentrations



The measurement of a cook's CO exposure in the EM study occurred 1 to 38 days after it was measured in the HPC study. Figure 6.2.3 compares the EM and HPC results from the 132 households where both measurements were made. There were large differences between many of the repeated measurements, but

no trend in the differences between the repeated measurements as a function of the time between the measurements.

Figure 6.2.3: 24-hour average CO exposures measured in the HPC and EM studies.

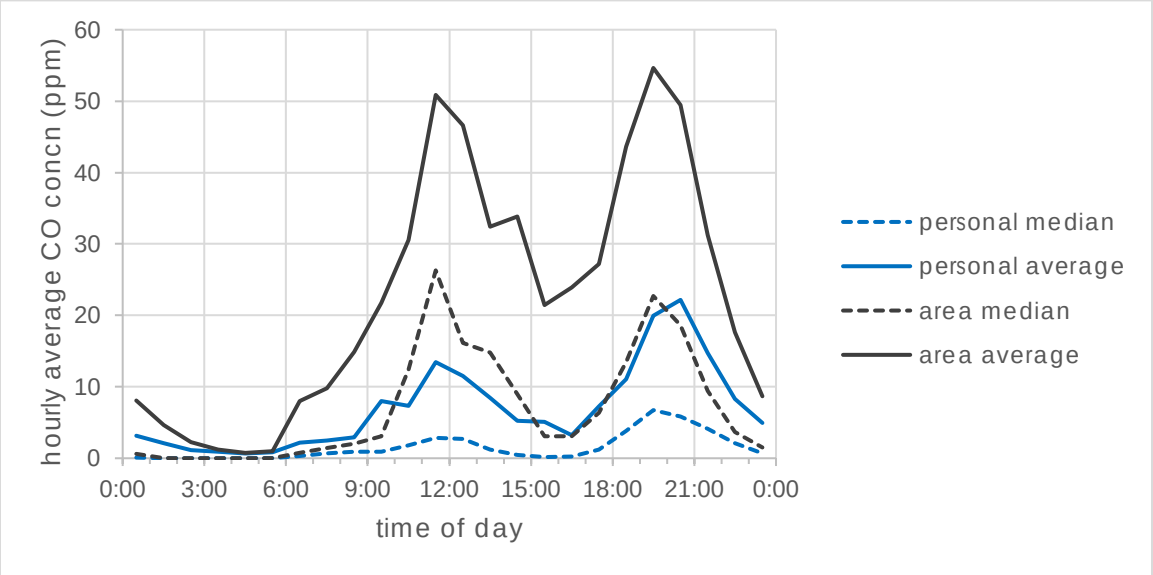


6.2.4 One-hour Average CO Results

In addition to a 24-hour average CO concentrations, hourly average CO concentrations were calculated for each hour of the day for each personal and area sample. Community patterns were determined by compiling hourly averages across all samples. Hourly average CO concentrations ranged from 0 to 524 ppm for the personal samples (N=3888, 24 hourly average values for 162 cooks) and from 0 to 421 ppm for the area samples (N=1368, 24 hourly average values for 57 cooking areas). The median, average, and standard deviation of the hourly average CO exposures for the cooks were 1.0, 7.0, and 23.8 ppm, respectively. The median, average, and standard deviation of the hourly average CO concentrations for the area samples were 2.9, 22.7, and 47.8 ppm, respectively.

Daily temporal hourly average concentration trends across the community are shown in Figure 6.2.4. This figure shows the median and average hourly average CO concentrations for each hour of the day for the personal and area samples in the EM study. Two peaks in CO concentration occur around noon and the early evening.

Figure 6.2.4: Median and average hourly average CO concentrations for each hour of the day for the personal and area samples in the EM study.



6.3 Particulate Matter (PM2.5) Concentrations

Overview

Samples of particulate matter with aerodynamic diameters smaller than 2.5 μm (PM2.5) were collected on Teflon filters over a 24-hour period. PM2.5 samples were collected on the main cook at all 180 EM households and collected near household stoves in 60 of the 180 EM households. Similar to the CO monitoring effort, samples were lost due to issues with the pumps (e.g., batteries and tubing) and issues with information related to the samples (e.g., poorly recorded start times and dates). There were 157 valid samples from monitoring the PM2.5 exposure of the main cooks (i.e., personal samples) and 56 valid data files from monitoring the PM2.5 concentration near household stoves (i.e., area samples).

24-hour Average PM2.5 Results

A 24-hour average PM2.5 concentration was calculated from each of the valid samples for the personal and area samples. 24-hour average PM2.5 exposures for the main cooks (i.e., personal samples) ranged from 32 to 860 μm m^{-3}. The median, average, and standard deviation of the 157 personal samples were 140, 165, and 113 μm m^{-3}, respectively. 24-hour average PM2.5 concentrations measured near household stoves ranged from 184 to 3137 μm m^{-3}. The median, average, and standard deviation of the 56 area samples were 477, 773, and 653 μm m^{-3}, respectively. Figure 6.3.1 shows the cumulative distributions for the two data sets. The median personal to area concentration ratio in the 46 households where both personal and area samples were collected was 0.23 (average of 0.30 and standard deviation of 0.21). Figure 6.3.2 shows the relationship between personal and area 24-hour average PM2.5 concentrations.

Figure 6.3.1: Cumulative distributions of 24-hour average PM2.5 concentrations for area and personal samples from the EM households

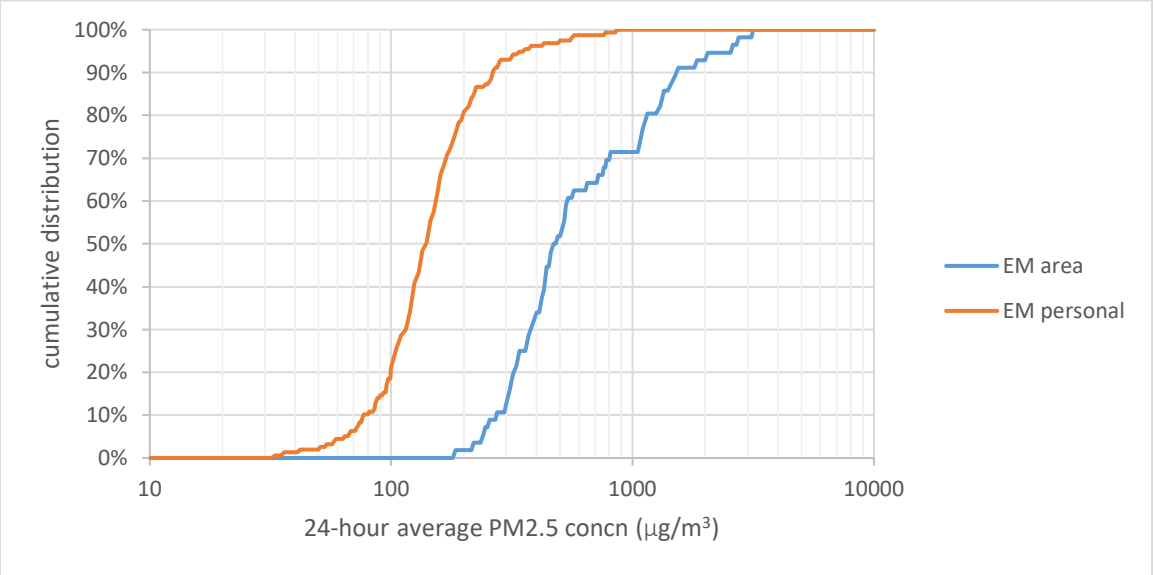
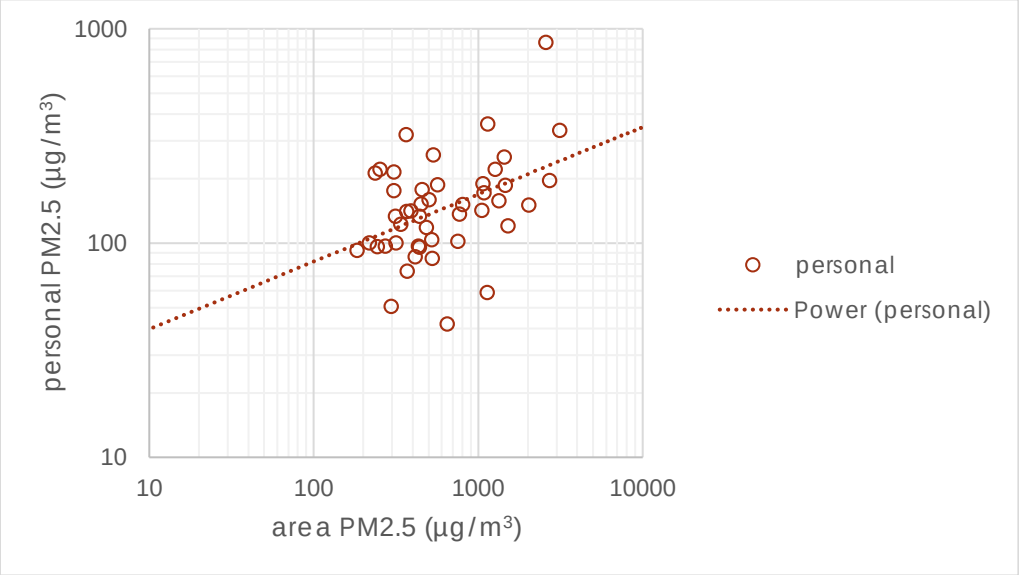


Figure 6.3.2: 24-hour average personal PM2.5 exposure as a function of 24-hour average area PM2.5 concentration



6.4 Polycyclic Aromatic Hydrocarbon (PAH) Exposure

Polycyclic aromatic hydrocarbons (PAHs) were collected on SKC low-volume sorbent tubes containing a glass fiber pre-filter, XAD-2 resin, and two segments of polyurethane foam (PUF).

Figure 1 indicates that the three most important PAHs are Naphthalene, Phenanthrene and Acenaphthylene, and that cooking location has an important effect on exposures. For these three most common PAHs and two other high prevalence PAHs, exposure levels are much higher (and statistically

significant) in the indoor cooking areas. Note also that virtually all levels are highr than the recommended limit value of 0.20 mg/m3.

Figure 6.4.1: Distribution of PAH by cooking area

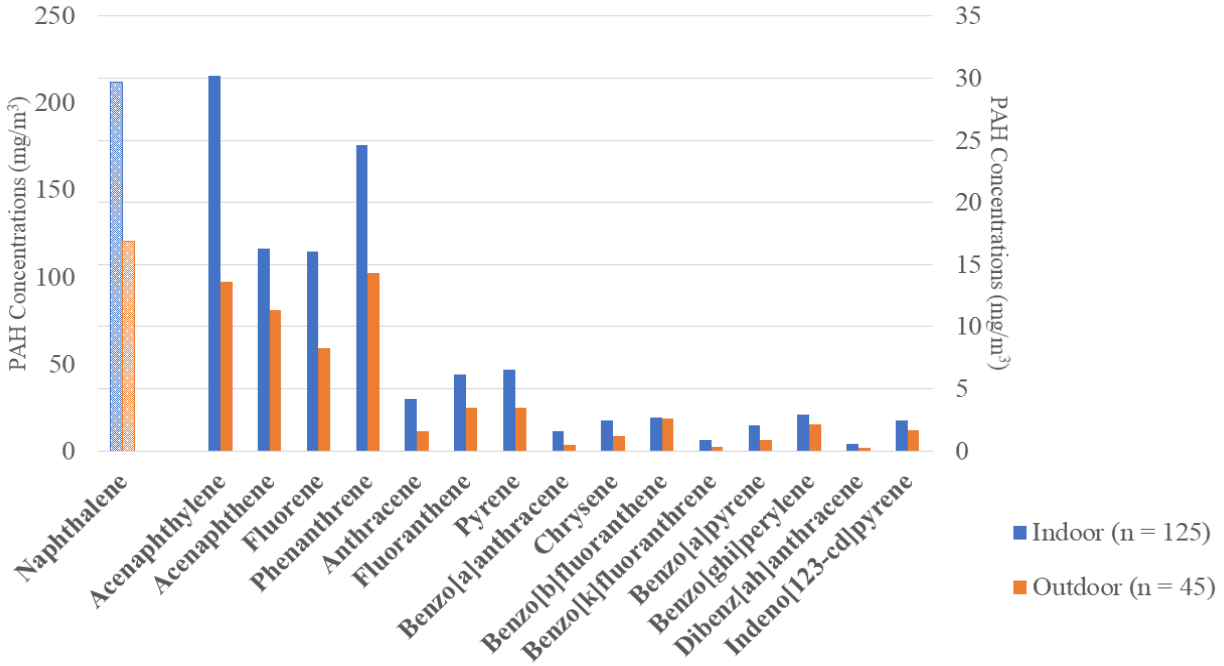
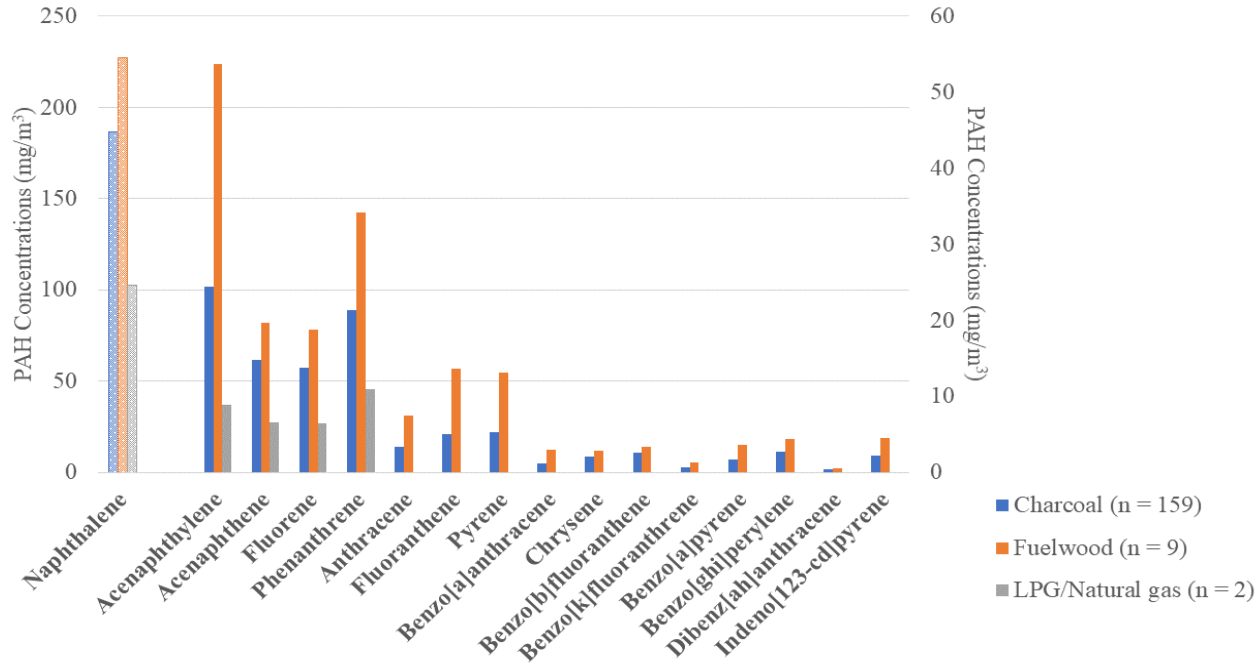


Figure 6.4.2.: PAH levels by fuel type



Analysis by main fuel type indicates that fuelwood generates the highest exposure levels, followed by charcoal, and the difference is statistically significant (not shown). Exposure levels with natural gas is much lower though there were only two households that used natural gas as their main fuel type.

6.5 Stove Use Patterns

LabJack Digit-TL temperature data loggers were used to monitor temperatures on or near stoves. Temperature variations can be used as a surrogate of stove use patterns. The processing of the LabJack data files is ongoing.

7. Conclusion

This document provides basic information and summary statistics of a major assessment of the Inyenyeri Clean Cook Stove Model currently being rolled out in Gisenyi town, Western Rwanda. The assessment is based on a randomized encouragement design. Households in Gisenyi were first randomly sampled for selection into the study sample. Two-thirds of this sample were then randomly assigned to receive a home visit from an Inyenyeri sales staff to learn about the stove.

8. References

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