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Monitoring and Evaluation of Comunidad Connect's Nica Agua Program

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Abstract

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Connect's Nica Agua Program
By Macklin McBride

Background: In Nicaragua, diarrheal illness is the fourth leading cause of communicable disease-related DALYs. A key component of diarrhea prevention is the use of safe drinking water, but rural Nicaragua has particularly low rates of access to safe water. Comunidad Connect is a non-governmental organization with multiple programs throughout Nicaragua, including one that seeks to improve access to safe drinking water by providing BioSand water filters to participants. This program, known as *Nica Agua*, lacks a robust monitoring and evaluation (M&E) system. This special studies project develops three M&E options for Comunidad Connect to consider in the evaluation of the Nica Agua program in Los Robles, Nicaragua.

Methods and Results: The development of the M&E plans first involved the creation of a logic model grounded in a behavioral change theoretical framework. Next, a logistical framework was developed to detail the activities of Nica Agua, the required monitoring of each step, and possible obstacles to the program. From this framework, three evaluation designs for the Nica Agua program were developed: a probability design with a stepped wedge implementation, a plausibility design with a neighboring community control, and an adequacy design. The procedures, advantages, disadvantages, and resource requirements of each option were discussed.

Discussion: The probability evaluation results are attributable to *Nica Agua* and the design preserves equality in terms of the distribution of filters. However, it is logistically complex and resource-intensive. By contrast, the plausibility design is less complex and requires fewer resources, but results cannot be definitively attributed to the program. Furthermore, the plausibility design lacks equality in that filters are not provided to controls. The adequacy design is simple, requires few resources, and provides filters to all participants, but evaluation results cannot be attributed to the program. Given these strengths and limitations, along with the goals and resources of Comunidad Connect, the plausibility design with a neighboring community control is recommended for Nica Agua. Once implemented, this evaluation project will guide Comunidad Connect's future efforts to address diarrheal illness in northern Nicaragua, as well as contribute to evidence-based practice for combating diarrheal illness in other settings.

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Chapter 1: Introduction

Background

Diarrheal illness constitutes a significant global burden of disease. In fact, of all communicable, maternal, neonatal, and nutritional diseases in 2019, diarrheal diseases were the second leading cause of global disability-adjusted life-years (DALYs) (Institute for Health Metrics and Evaluation (IHME), 2020). In 2017, the World Health Organization (WHO) stated diarrheal diseases were the second leading cause of death among children under five years of age, killing over half a million children under five annually (*Diarrhoeal Disease*, 2017). In Nicaragua specifically, the IHME Global Burden of Disease (GBD) lists diarrheal illness as the 4th leading cause of communicable disease-related DALYs in 2019.

Safe drinking water, sanitation, and hygiene (WASH) are widely recognized as key factors in preventing diarrheal illness (*Diarrhoeal Disease*, 2017). These preventative factors are so critical in disease prevention they are addressed by both the Sustainable Development Goal (SDG) 3.9— “by 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination” (United Nations General Assembly, 2015, p. 18)—and the SDG 6— “ensure availability and sustainable management of water and sanitation for all” (United Nations General Assembly, 2015, p. 20). But even though safe water and sanitation are recognized as vital components of health, they are still lacking in many countries. In 2017, fewer than 52% of Nicaraguan households used safely managed drinking water, defined as “drinking water from an improved water source which is located on premises, available when needed and free from faecal and priority chemical contamination.” (World Health Organization (WHO) and the United Nations Children’s Fund (UNICEF), 2017,

p. 8) Fewer than 30% used basic drinking water, defined as “drinking water from an improved source, provided collection time is not more than 30 minutes for a roundtrip including queuing” (World Health Organization (WHO) and the United Nations Children’s Fund (UNICEF), 2017, p. 8). When looking at rural Nicaragua, however, the rates are even lower. The Joint Monitoring Programme states fewer than 30% of households used safely managed drinking water and about the same percentage used basic water sources. Over 40% of households in rural Nicaragua are using water that is either unprotected or requires more than 30 minutes for collection time (Joint Monitoring Programme for Water Supply and Sanitation, 2017).

The *Nica Agua* Program

Comunidad Connect is a non-governmental organization with multiple programs in rural communities in Nicaragua and the Dominican Republic that address community health, youth empowerment, and sustainable community development. *Nica Agua* is a program by Comunidad Connect which seeks to improve access to safe drinking water in rural Nicaragua by providing BioSand water filters to program participants. To encourage community engagement, participants earn a filter by completing at least 16 hours of community service. Educational talks on WASH-related topics are provided to encourage the use of clean water, hygienic practices, and sanitary habits.

This researcher performed an on-site program evaluation of the *Nica Agua* program in summer of 2019. During the evaluation, employees of Comunidad connect shared that *Nica Agua* first began in 2013. Since then, the program boasts providing 7,000 people with access to clean drinking water and completion of 20,000 hours of community service by program participants (Comunidad Connect, 2017). *Nica Agua* was later paused in 2017 due to economic constraints. Currently, Comunidad Connect is planning to reinstate *Nica Agua*, beginning in Los Robles, Nicaragua.

Setting

According to Arguello et al., Nicaragua is the largest country in Central America (2020). It is also one of the poorest countries in Latin America. The Nicaraguan economy is suffering high levels of debt and unemployment, particularly after a long history of political unrest that persists today (Arguello et al., 2020).

Los Robles is a rural community in the department of Jinotega, in north-central Nicaragua. It is about 20km from the city of Jinotega. Due to its small size and remote location, there is a paucity of published information on Los Robles, but Comunidad Connect has a handbook for their volunteers that gives a brief summary of the community. According to Comunidad Connect, Los Robles is home to roughly 2,000 people, most of who work as farmers (Comunidad Connect, n.d.). Coffee is the most popular crop in Los Robles and during the harvest entire families work for about a collective $5 USD per day. Public buildings include two churches, schools, and a health clinic that was built in 2014. Within the community are a group of community health volunteers trained by the government and known as the “brigadistas.” The brigadistas support health outreach initiatives.

Purpose

Nica Agua has delivered many water filters to participants in the past, but it has lacked a robust monitoring and evaluation (M&E) system. A rigorous M&E system is important to identify the strengths of the program and areas for improvement, guide programmatic trajectory, and provide evidence of efficacy for funders and stakeholders. There is a need for evidence-based M&E of Comunidad Connect's *Nica Agua* program in Los Robles, Nicaragua.

The purpose of this special studies project is to develop an M&E plan to be used by Comunidad Connect when *Nica Agua* is reinstated. There will be three options for the M&E plan. The first and most rigorous option uses a probability design that randomizes all participants to either receive the BioSand Filter (BSF) or be part of the control group. The second option uses a plausibility design that allows *Nica Agua* staff to choose who will receive the BSF and who will be in the control group. The final option is the simplest but least rigorous. It is an adequacy design that forgoes a control group and compares participants before they received the filter to the same participants after they received the BSF. The second aim of this special studies project is to estimate the level of resources each option will require, as well as what inferences can reasonably be made from each approach. Finally, recommendations will be made for the monitoring and evaluation of the program moving forward.

Chapter 2: Literature Review

Burden of Inadequate Water, Sanitation and Hygiene

Inadequate water, sanitation, and hygiene (WASH) are significant contributors to the global burden of disease. In fact, these factors are so crucial to global health they are addressed by 10 different SDG targets, including 3.3, 3.9, 6.1 - 6.6, 6.a, and 6.b (United Nations General Assembly, 2015). The WHO estimates that in 2016 1.9 million deaths and 123 million DALYs were attributable to inadequate WASH (World Health Organization, 2019). In the same report, the WHO estimates this equates to 4.6% and 3.3% of 2016 global DALYs and deaths, respectively. In regards to children under 5 years of age, the percentage of global deaths attributable to inadequate WASH in 2016 was about 4 times that of the general population (World Health Organization, 2019).

Two of the major WASH-related contributors to the global burden of disease are diarrheal illness and acute upper respiratory infections (URIs) (Prüss-Ustün et al., 2019). While a substantial decrease in diarrhea-related mortality was seen from 2005 to 2015, diarrhea-related morbidity had a slower decline during the same timeframe (Troeger et al., 2017). Still, diarrheal illness was the second leading cause of all communicable, maternal, neonatal, and nutritional related DALYs globally in 2019 and URIs were the 18th (Institute for Health Metrics and Evaluation (IHME), 2020). In 2016, while URIs led to relatively few deaths—only 6,000 globally—there were 1.4 million global deaths attributable to diarrheal illness (World Health Organization, 2018).

Since not all sequelae from diarrheal illness and acute URIs are related to inadequate WASH, Prüss-Ustün et al. (2019) attempted to estimate the contribution of inadequate WASH to these two disease processes. The authors began by estimating the burden of acute URIs attributable to inadequate hygiene—defined as inadequate hand, face, food, and bathing hygiene. Prüss-Ustün et al. estimated that over 370,000 global deaths and over 17 million global DALYs were attributable to acute URIs secondary to poor hygiene. When looking at acute URIs resulting from poor hygiene in low- and middle-income countries (LMICs) in the Americas specifically, Prüss-Ustün et al. (2019) estimated they accounted for 25,000 deaths and 683,000 DALYs in 2016. Acute URIs resulting from poor hygiene are obviously a major contributor to the WASH-attributable burden of disease.

Next, Prüss-Ustün et al. estimated deaths and DALYs across LMICs in 2016 resulting from diarrheal disease, broken down by WASH component and geographical region. Diarrheal disease resulting from unclean water led to nearly 485,000 deaths and 30 million DALYs, while diarrheal disease from inadequate sanitation led to nearly 432,000 deaths and 26 million DALYs, and diarrheal disease from inadequate hygiene led to 165,000 deaths and nearly 10 million DALYs (Prüss-Ustün et al., 2019). When estimating 2016 WASH-related deaths and DALYs by region, LMICs in the Americas accounted for nearly 10,000 diarrhea-related deaths and 799,000 diarrhea-related DALYs. Prüss-Ustün et al. concluded that 60% of all diarrhea-related deaths in 2016 were attributable to inadequate WASH. It is clear inadequate WASH practices contribute significantly to the burden of disease in LMICs, including LMICs in the Americas specifically, via respiratory infections and diarrheal illness.

Pathogens Involved in Diarrheal Illness

There are numerous pathogens that can cause diarrheal illness, most of which can be transmitted via untreated water. These pathogens may be bacterial, viral, protozoan, or helminthic (*Guidelines for Drinking-Water Quality: Fourth Edition Incorporating the First Addendum*, 2017). The most common pathogens that lead to diarrheal illness vary by geography. For example, one review found rotavirus, *Cryptosporidium spp*, *Shigella spp*, and adenovirus to be the four leading causes of diarrheal death in children under five years old in 2015 (Troeger et al., 2017). However, a study evaluating etiology of diarrheal disease from 2007-2011 in sub-Saharan Africa and south Asia found the four pathogens that most commonly caused moderate-to-severe diarrhea in children under five years old—which was associated with a much greater risk of death—were rotavirus, *Cryptosporidium spp*, enterotoxigenic *E. coli* (ETEC) producing heat-stable toxin, and *Shigella spp* (Kotloff et al., 2013). In Nicaragua specifically, *Vibrio cholera* was the number one cause of diarrheal death in children under five years old in 2015, with ETEC, salmonella, and *Shigella spp* as second, third, and fourth, respectively (Troeger et al., 2017).

Walker et al. conducted a systematic review evaluating the presence of various pathogens globally among those above the age of five with diarrhea, separated into inpatient and outpatient (Walker et al., 2010). Among those hospitalized for diarrhea, ETEC and *V. cholera* were the two most commonly found pathogens, accounting for nearly half of all diarrhea-related hospitalizations in LMICs (Walker et al., 2010). The same study found the most common pathogens associated with diarrhea treated in the outpatient setting to be salmonella, *Shigella spp,* and *E. histolytica.* A notable limitation is that these pathogens may be associated with an increase in medical attention-seeking, which would lead to an overestimation of the burden of disease attributable to these pathogens in this study. There is a paucity of literature on the most common diarrhea-causing pathogens in people over five years old in the community setting. Additionally, literature on the most common diarrhea-causing pathogens specific to Nicaragua, whether inpatient or outpatient, in people over five years old is lacking.

Evidence for Water Treatment Methods

Many different methods exist to improve the quality of drinking water. These methods are generally divided into two categories: source-based and point-of use. Source-based interventions include any intervention that aims to improve water quality from a central point that is then collected or distributed to many people. For example, construction of a protected community well or chlorination of a community water-collection point are considered source-based interventions. Point-of-use interventions include any intervention that aims to improve water quality at the individual or household level. Examples of source-based interventions include water filters, chlorination at the household, or flocculation.

A Cochrane review of water quality interventions evaluated the evidence provided by 52 studies for various types of water treatment interventions, largely in rural LMICs, with diarrhea as the primary outcome (Clasen et al., 2015). In addition, this study rated the quality of evidence for each intervention. Quality was rated using the GRADE working group grades of evidence, which includes "very low quality," "low quality," "moderate quality," and "high quality" (Guyatt et al., 2008).

Among the six studies included on source-based water treatment, there was very low-quality evidence for a mild reduction of diarrheal episodes (Clasen et al., 2015). The review found point of use (POU) chlorination to reduce episodes of diarrhea by about 25%, though the evidence was low quality. Leaving plastic bottles of water in the sun to disinfect, a strategy known as SODIS, has an estimated 33% reduction in episodes of diarrhea, with moderate-quality evidence. The most significant impact was seen in POU water filtration, including ceramic, biosand, and LifeStraw® filters. There is an estimated reduction of approximately 50% of cases of diarrhea when using water filters, with moderate-quality evidence.

Clasen et al. warn that the results may vary significantly depending on other factors, such as setting, program implementation, and provision of water storage. They also note that the long-term impact of any intervention is not understood and needs further study.

Existing WASH programs in Nicaragua

Considering diarrhea's significant global burden of disease (Institute for Health Metrics and Evaluation (IHME), 2020) and the evidence that water treatment can reduce episodes of diarrhea (Clasen et al., 2015), WASH interventions are a popular strategy to combat diarrheal disease in LMICs. For example, A number of non-governmental organizations are working to improve WASH in Nicaragua. Water for People is an organization that is working in two districts in Nicaragua, San Rafael del Norte and La Concordia (Water for People, n.d.). As stated on their webpage, Water for People aims to construct piped water systems in these two districts, as well as create microfinance opportunities to improve sanitation and promote hygiene in classrooms.

Living Water International is a faith-based organization that works in Leòn, Somotillo, Granada, and Rivas (Living Water International, n.d.). This organization seeks to improve access to water through drilling boreholes and improving existing water sources. It also develops church-based care groups to promote sanitation and hygiene principles (Living Water International, n.d.).

Global Brigades is an international non-profit that currently runs medical and dental programs in Los Robles and is in the planning phase of implementing a water program there (Global Brigades, n.d.-b). The water program does not yet have a start date, but will include construction of a clean water system, identification and training of WASH leaders, and other WASH-related projects (Global Brigades, n.d.-b, n.d.-a). To the best of this researcher's knowledge, this is the only organization outside of Comunidad Connect that has current and/or planned programs in Los Robles.

Biosand Interventions in Nicaragua

Biosand filters (BSF) are water filters that use layers of sand and gravel to physically filter water, as well as a biolayer of microscopic organisms that kill pathogens (CAWST, n.d.). These filters have been found to be effective in reducing diarrheal illness (Clasen et al., 2015; O'Connell et al., 2017). However, local factors such as acceptance play a significant role in the efficacy of water treatment interventions. To the best of this researcher's knowledge, only two studies evaluating the BSF in Nicaragua have been published. The first was a cross-sectional study that took a convenience sample of 199 houses in rural southern Nicaragua that had been provided the BSF between 0-2 years prior and performed microbiological testing to identify colonies of *E coli* (Fiore et al., 2010). The study also conducted interviews during home visits to evaluate participant health, attitude toward the filter, and rates of filter use. Fiore et al found that

23% of households reported no longer using their BSF at the time of the home visit, primarily due to technical difficulties (no replacement sand, non-functioning). The study also found reported attitudes toward and use of the BSF to be inconsistent with objective data such as observed use and laboratory data, which the authors speculated was due to courtesy bias. Another significant finding of this study was a difference in colony-forming units (CFUs) of *E. coli* in samples collected from the tap versus those collected from the water storage containers, suggesting re-contamination occurred when storing the filtered water.

The second BSF study conducted in Nicaragua compared the BSF in Nicaragua to an electrochlorinator in Haiti and a ceramic filter with a bromine disinfectant in both Kenya and Haiti (Murray et al., 2020). Murray et al determined reported use via follow-up interviews, confirmed use via observation of water in the filter during home visits, and microbiological effectiveness via water sample testing for E. coli. Consistent use was defined as the proportion of follow-ups with confirmed use. For example, 100% consistent use was defined as observed water in the filter at 4/4 follow-up home visits. Murray et al. reported the BSF consistently had higher rates of confirmed use than the two other technologies, including 72% of households with 100% consistent use. Only 2% of households with the electrochlorinator had 100% consistent use, versus 43% of Kenyan households and 33% of Haitian households with the ceramic filter. The study found a 101-fold increase in the odds of 100% consistent use at follow up if the participant reported using a household water treatment method at baseline. It also found a positive correlation between 100% consistent use and number of known water treatment methods at baseline, as well as a negative correlation between believing drinking water was safe at baseline and 100% consistent use. The BSF had the lowest rate of technical problems listed as the reason for discontinued use and the lowest rate of major problems (defined as requiring large repair or replacement) in households reporting problems with the treatment technologies. Behavioral reasons were the most cited reason for non-use, with device failure or difficulties as the second most common reason. In laboratory testing of water samples, the BSF had lower rates of undetectable *E. coli* in 100mL and <10 CFU/100mL (considered a low-risk sample) than either other treatment method. Notably, rates of diarrhea in the past week in Nicaraguan children <5 years old was low at baseline (8%), which may suggest lower levels of *E. coli* at baseline (Murray et al., 2020).

Murray et al (2020) note that limitations of the study include small sample size, lack of randomization, low E. coli concentrations in certain settings at baseline, courtesy bias, and an imperfect objective indicator when determining confirmed use. A couple additional limitations exist in this study, too. The first is confirmed use was defined as observing water in the filter during home visits, but there was no verification that the participants were actively or exclusively using this filtered water. The clinical significance of confirming filter use through observed water in the filter is unknown. The second additional limitation comes when attempting to use this study to compare the three water treatment technologies. The variation in study settings between the treatment technologies makes it difficult to determine if observed differences are due to the treatment technology itself or to the setting and population where the technology was used. Further study is necessary to compare these technologies in the same setting. Murray et al. concluded that further study is also needed to identify standard indicators of consistent use and microbiological effectiveness, as well as to identify a household water treatment intervention that is both used consistently and microbiologically effective.

WASH Indicators

Murray et al. (2020) follow the WHO recommendation of using *E. coli* as a fecal indicator to determine water quality (*Guidelines for Drinking-Water Quality: Fourth Edition Incorporating the First Addendum*, 2017). The WHO recommends this indicator because it is more realistic and cost-effective than determining water quality targets for specific pathogens (*Guidelines for Drinking-Water Quality: Fourth Edition Incorporating the First Addendum*, 2017). However, using *E. coli* as an indicator has its limitations. For example, some pathogens, especially viruses and protozoa, may be more resistant to water treatment, causing water to test negative for *E. coli* yet remain unsafe to drink (*Guidelines for Drinking-Water Quality: Fourth Edition Incorporating the First Addendum*, 2017). Furthermore, as Murray et al (2020) recognize, low starting concentrations make it difficult to compare reductions in *E. coli*. Still, *E. coli* has become a popular proxy for water quality.

While *E. coli* is the most common indicator for water quality, there are many standardized indicators for the other various components of WASH interventions. The Sustainable Development Goals have standardized indicators specific to each goal and target that provide validated measurements to track the progress of the SDGs (United Nations General Assembly, 2017). Standardized indicators for components of WASH have also published by many sources, including the WHO (*2018 Global Reference List of 100 Core Health Indicators (plus Health-Related SDGs)*, 2018), UNHCR for emergency/post-emergency settings (UNHCR, 2020), and the Measure Evaluation Project (Moreland & Curran, 2018). These standardized indicators are useful tools to track the progress or impact of WASH-related programs, regardless of setting or programmatic design.

Biosand Filter Indicators

Despite the abundance of WASH-related indicators, there is a lack of verified indicators for BSF functioning that are realistic for use in rural, low-income settings (O'Connell et al., 2017). However, the two studies evaluating BSF performance in Nicaragua have followed the recommendation of the WHO in its Guidelines for Drinking Water Quality (2017) by using *E. coli* as an indicator of water quality (Fiore et al., 2010; Murray et al., 2020).

One cross-sectional pilot study of 8 BSFs attempted to address the gap in useful BSF indicators by comparing six potential indicators to the INDEXX Colilert Quanti-trays (O'Connell et al., 2018). The tested indicators included Colilerts presence/absence (Coliert's P/A), Hach's hydrogen sulfide, alkalinity and hardness kits, a mettler Toledo EL-2 battery-powered pH meter, and Sigma Aldrich fluorescently labeled latex microspheres. This study found Coliert's P/A to be a more reliable indicator than the other methods. However, there was still significant variability in results, including 9 of 70 readings that were inconsistent with the Quanti-tray results at 36 hours, and 24 inconsistent readings at 48 hours. Furthermore, study limitations such as small sample size, non-adherence to intended sampling collection time, and limited number of samples collected require further study before using results to guide the monitoring of future BSF interventions.

Conclusion

Diarrheal disease is a major cause of morbidity and mortality world-wide. Many interventions have sought to reduce the incidence of diarrheal disease but POU water filters have been the most successful. Biosand filters in particular have been effective interventions in

Nicaragua, though consistent and continued use over time remain a challenge. While a few different non-governmental organizations are currently working to address insufficient WASH in Nicaragua, only Comunidad Connect is actively working in Los Robles. These organizations should seek to identify reliable indicators of consistent use of their interventions, then to refine programs to maximize use of the intervention over time.

Chapter 3: Methods and Results

Introduction

The primary purpose of this special studies project is to develop three options for monitoring and evaluation of *Nica Agua* by Comunidad Connect. The second aim of this special studies project is to estimate the level of resources each option will require, as well as what inferences can reasonably be made from each approach. The third aim is to provide recommendations for the monitoring and evaluation of the program moving forward.

To design these M&E plans, a logic model (Table 1) was developed to represent *Nica Agua's* theory of change. Next, a logistical framework was designed to determine which indicators and means of verification would be used in the M&E plans, as well as the relevant assumptions and risks associated with using the chosen methods. Lastly, three M&E plans founded on the logistical framework were developed, each requiring a different degree of program capacity and resources. This section includes the methods and results of each step of the M&E plan design.

Logic Model

The first step in the creation of this project was to define the theory of change upon which the activities of *Nica Agua* was founded and to create a logic model based off of that theory. The logic model starts with an "inputs" column, which contains Comunidad Connect's project-related assets, followed by "activities," which are the activities involved in the implementation of *Nica Agua*. The third column includes "outputs," which are direct results that occur when the activities are completed. Next, behavior change theory is used to determine the short-term and long-term outcomes that are expected to arise from the preceding activities and outputs. The final column of the logic model states the expected overall impact of the project. The logic model can be found in Table 1, below.

Inputs	Activities	Outputs	Short-term outcomes	Long-term Outcomes	Impacts
Three staff members: Manager Nurse Accountant Community health volunteers (*Brigadistas*) Filter materials	Community informed Participants enrolled at the clinic Filters built Participants completed community service hours Filters distributed to houses and public spaces Educational talks held discussing filtered water, hygiene, and sanitation	# of enrolled participants # of filters built # of people with a filter in their house # of community service hours completed # of people who attend educational talks on each subject	Participants have access to filtered water Participants have increased knowledge of water, sanitation, and hygiene	Participants exclusively drink filtered water Participants have improved personal, household, and food hygiene Participants practice improved sanitation habits	Decrease in diarrheal illness in participants of Los Robles, Nicaragua

Table 1: Nica Agua Logic Model

Inputs

The inputs column lists the assets at the disposal of Comunidad Connect to help implement Nica Agua. Three staff members are assigned to the Nica Agua program: a program manager to oversee the program, an accountant to manage the program budget, and a nurse that works at the clinic in Los Robles to assist with the educational talks. These three staff members are also in charge of constructing the BSFs. Others may assist with the construction of the filters but must first be properly trained by program staff. Additionally, the government of Nicaragua has established community health volunteers known as *Brigadistas*. These volunteers are able to help with the activities of *Nica Agua*.

Activities

Nica Agua is composed of a few different activities. First, program staff will inform *Brigadistas* about the program, who will then spread the word within the community. Next, interested participants will be enrolled in the program by signing up with the nurse at the clinic. Sign-ups may be done over a period of one month or so—the exact duration is up to the discretion of the program staff. After enrollment, weekly educational talks on WASH topics will be held for participants. There will be five weekly WASH talks, one on each of the following topics: use of filtered water, food hygiene, hand hygiene, household hygiene, and human waste disposal. During this same period, the BSFs will be constructed by program staff. Participants will also be required to complete 16 hours of community service per household during this time. While the community service is not vital to the theory of change itself, it is considered an eligibility criteria of the program. Those unable to complete hours may have hours donated to them by other members of the community. After WASH talks, BSF construction, and community service hours are completed, the filters will then be delivered to participant's houses by program staff and *Brigadistas*. Each of these activities are then measured using the second column, outputs.

Outputs

Outputs are the direct results of the activities of the program. Each output is a measurement of the number of relevant activities completed. For example, participant enrollment can be measured by tracking the number of participants enrolled into the program. Similarly, records will be kept of the number of filters built, the number of people with a water filter in their house, and the number of people who attended the educational talks.

Outcomes

Outcomes are the intermediate changes expected as a result of the program. The outcomes for *Nica Agua* are separated into short-term and long-term outcomes. The short-term outcomes include increased access and knowledge, while long-term outcomes include behavior change. The determination of these outcomes—as well as the expected impact of the program on diarrheal illness—was based off of the Behavior Change Wheel developed by Michie, van Stralen, and West from University College London (Michie et al., 2011).

The Behavior Change Wheel is a theoretical framework aimed at providing a “method for characterizing and designing behavior change interventions” (Michie et al., 2011). The visual representation of the wheel may be found in Appendix A. In their framework, the authors outline three major components of behavior that serve as targets for intervention that they term COM-B:

capability, opportunity, and motivation. Each of these components further break down to areas, as seen in the Table 2 below:

Main COM-B category	**COM-B subcategory**	**COM-B subcategory description**
Capability:	Physical	The physical ability and skills necessary to perform the task in question
	Psychological	The mental capacity required to perform the task in question, including having the necessary knowledge
Opportunity:	Social	The social factors outside an individual's control that encourage or enable a behavior (e.g. social acceptance of the behavior)
	Physical	The physical factors outside of an individual's control that encourage or enable a behavior (e.g. conducive weather)
Motivation:	Automatic	The unconscious or habitual thoughts that prompt a given action, including emotional responses
	Reflective	The conscious, analytical, and goal-directed decisions an individual makes

Table 2. COM-B Categories (Michie et al., 2011)

In addition to identifying the COM-B system, Michie et al. identify nine intervention functions, which are methods for affecting the components of the COM-B system. The authors also identify seven policy categories, which are strategies for enabling the interventions. Each of the components of behavior may be affected by multiple interventions. Similarly, each intervention may be enabled by multiple policies.

Within the framework, Michie et al. posit that educational interventions bolster the psychological capability and reflective motivation of recipients, while interventions that enable recipients to make the desired behavior change support physical capability, psychological capability, physical opportunity, social opportunity, and automatic motivation. In the context of Nica Agua, the educational talks contribute to participants' psychologic capability and reflective motivation toward improved WASH. Therefore, the educational talks are expected to lead to the increase in WASH knowledge shown in the "short-term outcomes" and improved WASH behavior found in "long-term outcomes."

However, within the literature there is mixed evidence regarding the impact of educational talks on WASH knowledge and behavior change. The theory is supported by evidence that handwashing promotion leads to reduced episodes of diarrhea (Aiello et al., 2008; Ejemot-Nwadiaro et al., 2015) and that educational interventions related to hygiene and sanitation can positively influence behavior (Garn et al., 2017; Qazi & Anwar, n.d.; Sabogal et al., 2014). However, a systematic review by McMichael (2019) had mixed results regarding the impact of education on program participant behavior. Furthermore, a randomized controlled trial by Bowen et al. (2007) and a review by Ginja et al. (2019) suggested that addressing education and other cognitive processes alone are not sufficient to manifest significant changes in WASH-related behaviors (Bowen et al., 2007; Ginja et al., 2019). Because data on the effects of WASH education programs on behavior and diarrheal illness is inconsistent, further investigation is warranted to determine the impact of education in the context of Los Robles.

While the talks serve as WASH education, the distribution of water filters are classified as a form of enablement— specifically enabling the use of filtered water— within the behavior change wheel (Michie et al., 2011). Michie et al. (2011) assert that enablement may support physical opportunity, psychological capability, social opportunity, and automatic motivation. Through enablement, water filter distribution addresses the physical opportunity to have filtered water. Social opportunity is addressed in that filter distribution contributes to a culture of filtered water usage. Additionally, water filter distribution addresses automatic motivation by making filtered water available and therefore allowing its use to become reflexive. Through these various mechanisms, building and distributing BSFs is expected to improve access to and use of filtered water.

Although filter distribution is expected to increase access to and use of filtered water, it only does so if participants are able and willing to use the filters. A study by Fiore et al. (2010) found that after an average of 12 months, nearly one fourth of biosand filters in southern Nicaragua were no longer in use. The authors found the two primary reasons for non-use as lacking replacement sand (40%) and a broken filter or missing parts (20%). Also listed were ant infestation, undesirable taste, apathy, and no reason given (Fiore et al., 2010). However, Liang (2007) found more sustained use in a cross-sectional survey in Cambodia. The sustained use was associated with a few factors, including education on filter operation and maintenance, using an instrument to draw filtered water from the storage container, regular cleaning of the storage container, consistent use of the filter, and drawing water from a deep well (Liang, 2007). These conflicting results suggest BSF use is context-dependent and requires study in the Nica Agua target population to determine rates of non-use over time in the context of Los Robles. Once participants consistently use filtered water and practice safe hygiene and sanitation habits, improvements in water quality can be expected to contribute to improvement of diarrheal illnesses (Global Diarrhea Burden | CDC, 2018).

Logical Framework

To assist with development of the three M&E options, a logical framework (logframe) was developed based off of the logic model. The logframe can be found in Table 3. The first column of the logframe contains the narrative summary, which details the activities, outputs, outcomes, and goals of the program. The activities include the actions of the program. The outputs equate to the direct results that occur from the completion of the activities. The outcomes are the changes expected as a result of the outputs. The goal is the anticipated impact of the program.

The second column shows the indicators, which are specific data points that may be observed and measured to track progress toward the corresponding aspect of the narrative summary. These indicators will be used to determine the status and impact of the project. The third column contains the means of verification which will explain how the data for each indicator will be collected. The last column includes assumptions and risks, which are events outside the control or scope of the project that may interfere with the results or collection of M&E data.

Narrative Summary	**Indicators**	**Means of verification**	**Assumptions and risks**
Goal Reducing diarrheal illness in Nica Agua participants in Los Robles (LR), Nicaragua	**A.** Average # of days with diarrhea in the last seven days per person in the household	**A.** Baseline and Follow-up home visit records **B.** Monthly home visit records	Political instability does not interfere with the project
Outcomes **1.0** Participants exclusively drink	**1.0a** % of participants that used the BSF 24	**1.0a** Monthly home visit records	Participants accurately report their

filtered water consistently	hours prior to home visit for four consecutive months[1]		water, hygiene and sanitation habits There is not a source of improved or treated water aside from the BSF that impacts the program results (i.e. reported rates of diarrhea)
2.0 Participants practiced improved food, hand, and household hygiene habits consistently	**2.0a** % of participants who score 75% or greater on the hygiene questionnaire for four consecutive months	**2.0a** Monthly home visit records	
3.0 Participants used hygienic sanitation facilities consistently	**3.0a** % of participants who self-report using hygienic sanitation facilities for four consecutive months[2]	**3.0a** Monthly home visit records	
Outputs **1.1** Participants had access to filtered water	**1.1a** % of participants with access to a functioning BSF each month[1]	**1.1a** Records of rapid test kits at beginning, 6 months, and end **1.1b** Monthly home visit records	
1.2 Participants demonstrated understanding of importance of filtered water	**1.2a** % of participants that correctly identify which illnesses can be prevented by exclusively drinking filtered water (Appendix D)	**1.2a** Monthly home visit records	
2.1 Participants demonstrated knowledge of adequate food, hand, and household hygiene	**2.1a** % of participants that answer yes to all three food hygiene questions each month **2.1b** % of participants who	**2.1a** Monthly home visit records **2.1b** Monthly home visit records	Participants accurately report their water, hygiene and sanitation habits Residents regularly prepare their own food in-home

3.1 Participants demonstrated knowledge of adequate management of human feces	score at least 7/9 on hand hygiene each month **2.1c** % of participants that score at least 4/5 on house hygiene each month **3.1a** % of participants that answer yes to both questions on sanitation each month	**2.1c** Monthly home visit records **3.1a** Monthly home visit records	
Activities **1.1.1** Enrollment of participants	**1.1.1a** # of persons enrolled	**1.1.1a** Program records	Program records are properly maintained
1.1.2 Filters were built for interested households	**1.1.2a** # of filters built monthly	**1.1.2a** Records of tested and certified filters built	
1.1.3 Filters distributed to public spaces and participants after completion of community service hours	**1.1.3a** # of filters distributed monthly[1]	**1.1.3a** Records of tested and certified filters delivered	Residents of LR appropriately maintain filters
1.2.1 Educational talks discussing the importance of filtered water were held	**1.2.1a** # of talks held discussing filtered water monthly **2.1.1a** # of talks held discussing food hygiene monthly **2.1.2a** # of talks held discussing hand hygiene monthly	**1.2.1a** Program records of educational talks held **2.1.1a** Program records of educational talks held	Those who attend the educational talks will have the resources to implement what they learned (soap, cleaning supplies, bathrooms, etc.)

2.1.1 Educational talks discussing the importance of food hygiene were held **2.1.2** Educational talks discussing the importance of washing your hands with soap after using the bathroom, before cooking/eating, and after touching raw meat were held **2.1.3** Educational talks discussing the risks of having animals and animal feces in the house as well as the importance of reducing flies in the house by minimizing exposed trash and food were held **3.1.1** Educational talks discussing adequate waste management were held	**2.1.3a** # of talks held discussing household hygiene monthly **3.1.1a** # of talks held discussing sanitation practices monthly	**2.1.2a** Program records of educational talks held **2.1.3a** Program records of educational talks held **3.1.1a** Program records of educational talks held	

[1]Adapted from Moreland & Curran (2018)

[2] Adapted from SDG indicator 6.2.1 (United Nations 2017)

[3]Adapted from SDG indicator 6.1.1 (United Nations 2017)

Table 3: Nica Agua Logistical Framework

Narrative Summary

The narrative summary includes activities, outputs, outcomes, and the goal. The activities of Nica Agua involve two components: distributing biosand filters and providing educational talks. The filter component includes the training of staff to build water filters, the building of filters, and distributing filters to eligible participants. The educational component involves 60-minute trainings on safe water, sanitation, and hygiene practices and their impact on individuals' health.

As the activities of the program are executed, the outputs of the program are expected to manifest. Construction and delivery of filters improve access to filtered water, while the educational talks will improve understanding of WASH-related topics.

Once the outputs are satisfied, the behavior change listed under outcomes is expected to occur. Increases in access to filtered water and understanding of its importance are anticipated to encourage participants to use filtered water consistently. Greater understanding of the importance of hygiene as it relates to food, the household, and handwashing should prompt the implementation of improved hygiene practices. Similarly, greater understanding of sanitary practices should contribute to the consistent use of sanitary practices.

As all outcomes are fulfilled the program should achieve its goal. Meaning, the consistent use of filtered water, hygienic practices, and sanitary habits are expected to cause a reduction in diarrheal illness in participants of the program throughout its duration.

Indicators

Indicators are a way to monitor if a program is completing its activities, outputs, outcomes, and goals as planned. Standard indicators were chosen when possible. The chosen indicators are SMART indicators, meaning they are specific, measurable, attributable, realistic, and time-bound.

One indicator from each section of the logical framework (goal, outcomes, outputs, activities) were chosen as examples to detail the SMART features. They are as follows:

1) **A**- Average # of days with diarrhea in the last seven days

   - Specific- This indicator directly compares the prevalence of self-reported diarrhea in participants of the program

   - Measurable- This indicator determines the quantity of days via the baseline and follow-up questionnaires

   - Attributable- This indicator is attributable because use of filtered water has been shown to reduce rates of diarrhea (Clasen et al., 2015)

   - Realistic- This indicator is realistic because it can be collected during the household interviews

   - Time-bound- This indicator specifies the last seven days

2) **1.0a** % of participants that used the BSF 24 hours prior to home visit for four consecutive months (Moreland & Curran, 2018).

   - Specific- This indicator identifies recent filtered water use in Nica Agua participants

   - Measurable- This indicator involves calculating a percentage using data collected during the home visits

   - Attributable- This indicator is attributable because BSF filters were provided by the program

   - Realistic- This indicator is realistic because the home visits are completed as part of the program

- Time-bound- This indicator specifies use of an improved water source in the past day and for a duration of at least four consecutive months. Use of the BSF will be asked about each month but this indicator will not be calculated until four months after delivery. After this time, it will be calculated each month to quickly capture changes in rates of use.

3) **1.1a** % of participants with access to a functioning BSF each month (Moreland & Curran, 2018)

- Specific- This indicator is specific because it directly identifies those with access to a functional BSF
- Measurable- This indicator uses as the numerator the number of participants who report using their filter regularly and whose filter is confirmed to be functional by a rapid water quality test kit. The denominator is the total number of participants
- Attributable- This indicator is attributable because improved sources of drinking water are being provided by the program
- Realistic- This indicator is realistic because it is cheap and quick to include the questions in the monthly visits. The water quality testing kits are also quick and easy to perform, but can be eliminated from the M&E plan if financial constraints require it. However, this will weaken the indicator as there is no way to validate that the filters are functioning to remove pathogens.
- Time-bound- Self reporting is done each month and water filters are tested every 6 months by those conducting the home interviews

4) 1.1.3a- Number of filters distributed monthly (Moreland & Curran, 2018)

- Specific- This indicator identifies water filters distributed by the program to participants

- Measurable- This indicator determines the quantity of filters distributed through programmatic records

- Attributable- Only filters distributed by the Nica Agua are counted

- Realistic- It is simple and free to maintain a log of the filters as they are distributed

- Time-bound- The number of filters is totaled each month

Means of Verification

The means of verification primarily come from two sources: program records and home visit records. Program records include a sign-in sheet at each educational talk for participants to verify they attended, which can also be used to verify that the talk occurred. Home visit records come from the monthly home visits conducted by Nica Agua staff to monitor the condition, use, and impact of the filters (Appendix C and D). Other means of verification include rapid water testing kits (1.1a) as a means to verify the safety of filtered water and programmatic records of filters built and distributed (1.1.2a, 1.1.3a).

Assumptions and risks

The assumptions and risks are primarily factors outside the control or scope of the project that may impact the implementation and/or efficacy of the project. The primary assumption relating to the goal of the project is that the current political instability in Nicaragua will not interfere with the implementation of the project. In regard to the outputs and outcomes, accurate M&E is dependent on the assumption that participants will accurately report their WASH-related habits without succumbing to courtesy or recall biases. Similarly, the assumption that participants are regularly preparing their own food in their homes must be true for accurate monitoring of hygienic food practices (2.1a). There are three assumptions associated with the activities. The first is that program records are properly maintained. Destruction of paper files or loss of digitized files would hinder the monitoring of the educational talks and filter construction and delivery. The second activity-related assumption is that participants will have the resources to implement what they learned during the educational talks. For example, if participants learn the importance of handwashing and critical times to implement handwashing but do not have the money for soap, this may confound the results of the project. The third activity-related assumption is that participants will properly maintain the BSF. They will be educated on maintenance upon receipt of the filter, but if the motivation to maintain the filter is lacking, the filter may eventually produce contaminated water and confound results. The project is designed to minimize these assumptions and risks but, with the exception of accurately maintained program records, they are largely outside the control and scope of Nica Agua.

Monitoring and Evaluation Plans

Founded upon the logframe, three M&E options were created for Comunidad Connect to choose from when implementing *Nica Agua* in Los Robles. The first option is a probability design with a stepped wedge implementation. With the probability design, participants are randomized to either a “treatment” or a “control” group. In this study, the treatment group includes receiving the BSF and educational talks on WASH topics, while the control group receives the educational talks but not a filter.

The probability design allows for the greatest amount of certainty that any changes in rates of diarrhea are attributable to *Nica Agua*. This is because the probability design is the only design that involves randomly allocating participants either to the treatment group that receives the intervention (e.g. the BSF and educational talks), or to the control group that does not receive the intervention. Based on biostatistical theory, the process of randomization ensures that the two groups have the same observable and non-observable characteristics. For example, both groups should have roughly equal observable characteristics such as average ages, male to female ratio, and baseline rates of diarrhea. However, they should also have roughly equal non-observable characteristics such as motivation, self-discipline, and initiative. These non-observable characteristics are important because they will affect the participants' behavior, therefore potentially affecting the outcome of the program, and can only be consistent between treatment and control groups with random allocation. For this reason, the probability design is superior to the plausibility or adequacy designs in terms of attribution of results to the program.

The stepped wedge implementation is a method to ensure equality between treatment and control groups, because it ensures that every participant eventually receives a filter. In the stepped wedge design, participants are separated into groups and the BSF is incrementally provided to each group. Data is collected from each group at pre-determined points in time and those who have yet to receive a filter at each time point are used as the control group (Figure 1). While this design is logistically complicated to implement due to multiple stages of intervention delivery and careful tracking of which participants are in the intervention versus control groups, it is the most rigorous and equitable program design.

	Data Collection Round					
	R1	R2	R3	R4	R5	R6
Group 1	C	I	I	I	I	I
Group 2	C	C	I	I	I	I
Group 3	C	C	C	I	I	I
Group 4	C	C	C	C	I	I
Group 5	C	C	C	C	C	I
Group 6	C	C	C	C	C	C

C= Control; I= Intervention; R= Round of Intervention

Figure 1. Example of Stepped Wedge Design (Freeman, 2019)

In round one of implementation, the BSF has not yet been delivered and all groups serve as the control. In round two, filters are delivered to group one and the other groups remain the control. Incremental delivery continues until all groups have received a filter, leaving no more groups to act as the control.

Sample Size Calculation

There are many steps involved in the probability design, the first of which is to calculate the necessary sample size. However, calculation of sample size in this M&E plan is complex for three main reasons. First, the program involves more than one intervention, including the provision of water filters and educational talks on WASH topics, with various groups receiving the interventions at different times. Second, the indicators monitor at the individual level, but interviews are done by household. This makes it difficult to determine the degree of clustering that must be accounted for. Third, the stepped-wedge approach may affect the number of participants necessary, making it more difficult to determine the necessary sample size than in a standard randomized controlled trial (RCT). Due to the complexity of the program and M&E design, sample size calculation is outside the scope of this special studies project. Consultation with a biostatistician to calculate the necessary sample size is recommended.

Were this a standard RCT however, the sample size would be calculated using openepi.com's "Sample Size: X-Sectional, Cohort, & Randomized Clinical Trials" (*OpenEpi - Toolkit Shell for Developing New Applications*, n.d.). The box titled "Two-sided confidence level (%)" would be left at the default of 95, "Power (1-beta or % chance of detecting) at the default of 80, "Ratio of exposed to unexposed in sample" at 1.0, and "Percent of unexposed with outcome" would be set to the baseline level of diarrhea in the community. Lastly, the box titled "Percent of exposed with outcome" would be reflect the minimum acceptable design effect of the program. For example, if the baseline prevalence of diarrhea is determined to be 30% in the community and the program wants to see at least a 10% decrease in those who received the filter and WASH education, then "Percent of unexposed with outcome" would be set to 30 and "Percent of exposed with outcome" would be set to 20. The program can then calculate the necessary sample size and, using the "Kelsey" method of calculation in OpenEpi, the total sample size would be listed as 578.

Group Determination and Randomization

After consulting a biostatistician to determine the necessary sample size, the next step is determination of groups for the stepped wedge design. Staff will divide participants into either three, four, or six equal groups. This ensures delivery of filters to each group can be evenly spaced out over the course of 12 months, as demonstrated in the example timelines of Appendix

B. It is important that the program begins and ends at approximately the same time of year to reduce the risk of observing seasonal differences in rates of diarrhea, a documented phenomenon in certain diarrheal pathogens (Chao et al., 2019). The number of groups depends on the number of phases Nica Agua has the capacity to implement. For example, if program resources allow for three phases and 324 participants are enrolled, then each phase will contain 108 participants. Participants will be randomized into the phases. To do so, each enrolled participant will be assigned a number. Then, an online random number generator will be used to randomly select participants' assigned numbers. In the given example, the first 108 numbers selected will be allocated into the first phase and will therefore receive the BSF at the beginning of the project. The second 108 selected will receive the BSF in the second phase, and the third 108 will receive the filters during the last phase.

Once all participants are allocated to their groups, a baseline home visit will be completed by program staff and *Brigadistas*. These visits will use the "Baseline/Follow-up Visits" form found in Appendix C. The visits will provide information about baseline WASH practices and rates of diarrhea to be compared to post-intervention follow-up data.

After the baseline home visits are conducted, participants in the first phase will be required to complete their community service and attend the WASH educational talks. The participants receiving the BSFs in subsequent phases will complete community service hours and attend educational talks in the interval between filter delivery to the previous group and receipt of the filters. It is important that participants not attend the talks until their assigned time to ensure WASH behaviors are not influenced by the talks during baseline or monitoring.

While the WASH talks are being completed, *Nica Agua* staff will be constructing the BSF filters. After construction, filters will be delivered to each participant's house according to the chosen timeline from Appendix B. Beginning with the first round of filter deliveries, monthly home visits will be completed by the *Brigadistas* with all participating households. These monthly visits will use the “Home Visit” form found in Appendix D. After each phase of the program, *Nica Agua* staff will perform a review of the home visits since the last round of deliveries before. This monitoring system will help identify and address any problems that arise throughout the program, such as defects in the filters. Twelve months after the initial baseline evaluation is performed, the final group will receive their filters, a follow-up interview will be performed at all households using the form in Appendix C, and evaluation of the program will begin. As with the sample size calculation, the complexity of this program and its monitoring requires consultation with a biostatistician at the beginning of the program for proper data analysis of each group at each phase of the program.

Plausibility design

The second option for the M&E plan is a plausibility design. In this design, there is an intervention group that receives the BSF and educational talks and a control group that only receives the educational talks. Unlike in the probability design with stepped-wedge implementation, the two groups are unchanging and unrandomized. Instead, a neighboring community with similar characteristics as Los Robles, such as Datanlì, may be used as the control. Using a neighboring community reduces mingling between the intervention and control participants, which has the potential to confound results. While this M&E option allows for simpler implementation and minimizes confounding due to crossover, the plausibility design lacks the equality of the stepped wedge approach. Furthermore, this design only provides moderate evidence that changes in rates of diarrhea are attributable to the Nica Agua program due to the lack of randomization.

Similar to the probability design, the first step of the plausibility design is to calculate the necessary sample size. While this design does not include the complexity of the stepped-wedge approach, both the multi-modal intervention and individual-level indicators with household-level surveys complicate the sample size calculation to beyond the scope of this project. As in the probability design, consultation with a biostatistician is recommended to determine the proper sample size for the plausibility design. Once the sample size is determined, the *Brigadistas* can help raise awareness of the program in the community and enrollment can occur by encouraging interested individuals to sign up at the community clinic.

After enrollment, implementation of the plausibility design is similar to the probability design in that program staff will construct and deliver the BSFs, as well as work with the *Brigadistas* to conduct baseline home visits (appendix C), monthly home visits (appendix D), and final home visits (appendix C). Just as in the probability design, it is still important that the baseline and final home visits are at approximately the same time of year to reduce the risk of observing seasonal differences in rates of diarrhea. Participants in the intervention group will still complete community service hours and attend educational talks prior to receiving the BSF, while those in the control group will do neither. Aside from randomization, the primary difference between implementation of the probability and the plausibility design is that all participants in the intervention group receive the BSF at the same time in the plausibility design, rather than the stepped wedge approach of the probability design. Another minor difference in this design is that a review of the monthly home visit (Appendix D) will be completed by program staff after each month to identify and address common problems that arise throughout the program, such as improper maintenance of the filter.

After completion of all final home visits, program evaluation will begin. Evaluation of the program will include a difference-in-difference (DiD) analysis. A DiD analysis calculates the change in the intervention group from baseline to follow-up and compares it to the change in control group during the same time period. For example, the average number of days with diarrhea in the past 7 days (Table 3- Indicator A) at baseline can be subtracted from Indicator A at the final home visit in both the intervention and control groups. Then, the change in the control group can be subtracted from the change in the intervention group to determine the effect of the program. This can be mathematically expressed as:

$$(Indicator\ A_{intervention,final} - Indicator\ A_{intervention,baseline}) - (Indicator\ A_{control,final} - Indicator\ A_{control,baseline}) = Effect\ of\ program$$

After calculation of the DiD, statistical software such as *R* or *SAS* will be used to calculate the statistical significance of the program's effect.

Adequacy Design

The final M&E option is an adequacy design. This design does not involve a separate control group but instead uses baseline data from participants prior to receiving the BSF and compares it to data collected from the same participants after receipt of the filter. This design is the simplest to implement and maintains equality through universal provision of the BSF to participants, but it cannot determine if changes in the rate of diarrhea are attributable to Nica Agua.

The steps involved with an adequacy design are similar to that of the probability and plausibility designs. The main exception is that a sample size will not be calculated. The adequacy design does not evaluate for statistical significance and therefore the sample size is determined by how many participants the program can support. After determining the size of the program, the *Brigadistas* will raise awareness of the opportunity in the community and encourage interested individuals to enroll at the community health clinic. Then program staff and the *Brigadistas* will complete the baseline home visits, after which participants will complete community service and attend WASH educational talks. Next, the BSF filter will be delivered to all participants. Monthly visits will be conducted, after which there will be a review to address issues in real time. One year after baseline visits are completed, a round of final home visits will be conducted. Finally, an evaluation will be performed to compare average rates of diarrhea in the past 7 days at the end of the program to the average rates at baseline. Comunidad Connect can then identify whether or not there was a difference from baseline to follow-up. However, any difference in the rate of diarrhea cannot be attributed to Nica Agua since there was no control group to determine what happened to rates of diarrhea in the entire community.

Conclusion

The development of a selection of monitoring and evaluation plans was a multi-step process. First, a logic model logic grounded in a behavioral change theoretical framework was developed as a visual representation of the program's actions and desired results. Second, a logistical framework was developed based off the logic model to detail the steps of *Nica Agua,* the required monitoring of each step, and possible obstacles that may interfere at each step. From this logistical framework was developed the three different options for the M&E of *Nica Agua:* a probability design with a stepped-wedge implementation, and plausibility design with a neighboring community control, and an adequacy design. These options range from highly resource-intensive to minimally resource-intensive, each with a varying level of attributability of results to the program. Comunidad Connect may determine which option suits its needs based on available resources and level of attributability required by stakeholders.

Chapter 4: Discussion

Introduction

The water filter distribution program *Nica Agua* has provided many water filters to homes in rural northern Nicaragua prior to its temporary discontinuation. However, it has lacked a formal method of monitoring and evaluating its outcomes. The goal of this special studies project was to address this deficit through the development of three M&E options after the reinstatement of the *Nica Agua* program. To meet this goal, a rigorous yet resource-intensive probability design with a stepped wedge implementation, an intermediate plausibility design with a difference-in-difference evaluation, and an adequacy design were designed.

This special studies project had two additional aims. The first was to estimate the level of resources each option would require, as well as what inferences could reasonably be made from each approach. The second was to provide recommendations for the monitoring and evaluation of *Nica Agua* moving forward. These two additional aims will be accomplished in this section.

Logic Model

The logic model illustrated in this special studies project demonstrates the theory of change from inputs and activities, to outputs and outcomes, and finally to the desired impact of the program. Having a visual representation of the theory of change upon which *Nica Agua* was founded allows for a clear understanding of necessary steps to reach the desired outcome. It also serves as the basis for the development of the logistical framework.

Logistical Framework

The logistical framework created during this project details each step of *Nica Agua*, as well as the indicators used to measure the progress of each step, how those indicators are verified, and any assumptions and risks that may affect the program. The development of this framework was vital to the creation of the M&E plans in that it defines the specific data necessary to determine if the program is progressing toward its goal of reducing diarrheal illness.

Monitoring and Evaluation Plans

Structured monitoring and evaluation of a program is critical to the improvement and continued success of the program. Monitoring allows the program to identify and address problems in real time. In the case of *Nica Agua*, regular monthly home visits allow staff to recognize when participants have not used their biosand filter or when the filter is broken, and to encourage use of the filter or assist in fixing it. Through monitoring, the program continues to proceed as planned, encouraging and enabling participants in the intervention group to use the filter.

Evaluation, on the other hand, determines the impact of the program. Thorough evaluation may support continuation of a program if a positive impact is found, or it may support reallocation of resources if there is no evidence for the primary expected outcomes. This information may be used when approaching key stakeholders and potential funders. Additionally, a program may determine ways to improve subsequent iterations of the program during its evaluation. Thorough evaluation is a vital component of evidence-based practice.

Strengths and Limitations

Each monitoring and evaluation plan has strengths and limitations. In general, the more rigorous an M&E plan is the more resource-intensive it is. This is the case with the probability, plausibility, and adequacy designs described in this special studies project.

The probability design with the step-wedge implementation is indeed the most rigorous, but also the most resource-intensive. One significant benefit of this design is that it provides the highest level of attributability to the program by including randomization of participants to groups. This means any changes seen between intervention and control groups can reasonably be assumed to be a result of *Nica Agua*. Another significant benefit is that the stepped wedge implementation preserves equality. Though not every participant receives a filter at the beginning of the stepped wedge design, they all receive one by the end.

There are several limitations to the probability design, however. For example, the stepped wedge implementation requires multiple stages of filter delivery, which is logistically complex. It requires careful tracking of which participants are in the control group and which are in the intervention group at each phase of the program. The need for careful tracking increases the amount of time and effort required from program staff. The probability design also requires more time from program staff in that staff must build filters, deliver them, and give educational WASH talks throughout the program rather than at the beginning. Additionally, the probability design is a costly design. While providing a filter to every participant preserves equality, providing more filters increases the cost of the program. Consultation with a biostatistician to determine the sample size is also likely to increase the cost associated with the probability design.

The plausibility design with the difference-in-difference evaluation has its own set of strengths and limitations. These center around it being a design of moderation in terms attributability and logistical complexity. The plausibility design maintains a moderate level of attributability to the program, though not quite as much as the probability design. This means the effects measured during the program can be interpreted as likely being due to *Nica Agua*.

The plausibility design is also a moderate option in terms of complexity of implementation. This design is simpler than the probability design in that it does not involve multiple phases of delivering the intervention. Conversely, using a neighboring community as a control group is somewhat more logistically complex than remaining in one community in that it requires program staff to split their time between the two communities. Not only is more time required of staff, but program cost increases as more gasoline is required to travel to a separate community. Program cost is also impacted by the need to consult a biostatistician to determine the sample size as part of the plausibility design.

Despite increasing the complexity, use of another community as a control group does confer additional benefits. By using a neighboring community, members of the control group are less likely to drink filtered water from those in the intervention group. Such cross-over between the intervention and control groups negatively impacts the integrity of the study and validity of its results. Another benefit of using a neighboring community as a control group is that there is little risk of perceived favoritism among participants in Los Robles. Whereas the probability design risks disappointing participants who are not randomly selected to receive the intervention, the probability design clearly designates who will and who will not receive the filter at the start of the program.

Aside from not providing the same level of attributability as the probability design and being more resource-intensive than the adequacy design, there is one other major limitation of the plausibility design: it lacks equality. This design does not provide a filter to all participants of the evaluation. Instead, it leaves the control group without any compensation for their participation. Comunidad Connect staff has voiced concern in the past about asking a community to participate in an evaluation without offering them some form of compensation, making this an important limitation of the plausibility design.

The most simple and least resource-intensive of the three design options is the adequacy design. This option only requires an intervention group, making tracking of participants and delivery of the interventions uncomplicated. Foregoing a control group also spares the adequacy design the need to consult a biostatistician to determine the sample size, which reduces the cost of the program. Furthermore, this design maintains the highest level of equality by providing a filter to all participants of the program at the same time.

Despite its many advantages, the adequacy design has one significant limitation. Because it lacks a control group, the adequacy design does not provide any attribution to the *Nica Agua* program. Instead, this design can only determine if there was a change in rates of diarrheal illness from baseline to follow-up. It does not provide any evidence as to the cause of the change. In the adequacy design, attributability is sacrificed for simplicity and equality.

Recommendations

Because each monitoring and evaluation plan has different strengths and limitations, the specific needs, desires, and available resources of Comunidad Connect must be considered when selecting which design to use. For example, if the goal of Comunidad Connect is to publish the research as evidence for or against use of the interventions in the reduction of diarrheal illness, then the probability design would be ideal as it is the most scientifically rigorous option. If the goal is to determine the provision and utilization of the interventions along with general changes in the rate of diarrhea without the need to determine if the program itself had an effect, then the adequacy design would be optimal. However, from this researcher's time with Comunidad Connect, these two designs do not seem to align with the goal of the program. Instead, the goal is to have a general idea of *Nica Agua's* impact on rates of diarrhea. Therefore, the plausibility design is recommended.

Aside from aligning with the general goal of the program, the plausibility design is a fitting option for *Nica Agua* for two reasons. First, this design is sufficient for the program to use as evidence for potential donors. The plausibility design provides moderate evidence of the impact of the program, but because no other organizations are providing interventions in Los Robles it is likely that observed changes are a result of the intervention. Comunidad Connect is largely donor funded, so the ability to demonstrate its impact in the community may help raise support. If *Nica Agua* has a positive impact, the plausibility design provides sufficient evidence to encourage donors to support its efforts. If there is no evidence of a positive impact, this design allows the program to identify opportunities for improvement. These opportunities for improvement, along with the estimated cost of the improvements, may be beneficial when discussing needs of the program with potential donors. This ability to reasonably attribute results of the evaluation to *Nica Agua* makes the plausibility design better suited to Comunidad Connect's needs.

Secondly, the plausibility design requires less time from program staff compared to the probability design. There is only one round of filter construction and deliveries in the plausibility design, whereas in the probability design filters are constructed and delivered at each phase of the program. While the plausibility design requires more time to travel to a neighboring community to complete home visits, suitable communities are only a few minutes away. Therefore, it is feasible for Nica Agua staff to visit both communities in one day. Because of the proximity of the communities, monitoring both is still less time-consuming than the continual filter construction and multiple rounds of WASH talks required by the probability design. Minimizing the time required of program staff for M&E is essential, as the staff only consists of three people.

While the plausibility design is recommended for the monitoring and evaluation of *Nica Agua*, there are many ways in which Comunidad Connect may adapt the design as necessary to fit the program's needs. For example, to address concerns of equality in the plausibility design, Comunidad Connect may choose to distribute filters to the control group after the study is completed. Alternatively, other non-WASH related incentives may be offered to compensate members of the control group for participating in the evaluation. The cost of the program would increase with the addition of filters or incentives, but it would address the problem of equality. Another possible adaptation would be to collaborate with partners from academic institutions for sample size determination rather than hiring a consultant. By avoiding the hire of a biostatistician, the cost of the program decreases. While Comunidad Connect may adapt the plausibility design for this round of *Nica Agua*, it may choose to use one of the other designs for future iterations of the program. This flexibility allows the program to address changing needs as they arise.

Next Steps

There are only a few steps necessary before Comunidad Connect is ready to implement a monitoring and evaluation plan for *Nica Agua*. The first is to determine which M&E design is most appropriate for the program. The plausibility design is recommended based on this researcher's experience with Comunidad Connect and the perceived goals of the program. However, Comunidad Connect staff must determine what is best for the program given the strengths and limitations of each design, as well as how those align with the needs, goals, and available resources of the program.

After choosing an M&E design, the initial preparations for *Nica Agua* may begin. These include consultation with a biostatistician to determine the required sample size. They also include determining the timeline of the program and evaluation. Fundraising for the program, including the additional M&E expenses, should also be completed during these initial preparations, as well as translation of the M&E materials into Spanish. Once these initial preparations are completed, the program is ready to begin and the chosen M&E design can be followed as outlined.

Limitations

There are a few primary limitations of this special studies project. The first and most significant is that all three monitoring and evaluation designs rely on self-reported measures. Self-reporting is subject to multiple types of bias, including social desirability, courtesy, and recall biases. Self-reporting is also subject to interpersonal variability, especially in the setting of self-reported diarrhea. However, measuring rates of diarrhea without using self-reported measures is extremely challenging. Furthermore, interpersonal variability is minimized by defining diarrhea for each participant on the baseline/follow-up questionnaires (Appendix C).

The second limitation to this special studies project is the potential for cross-over among participants. Members of the intervention group may drink unfiltered water when away from home and members of the control group—when using an M&E design with a control group—may drink filtered water at the house of participants. The plausibility design attempts to minimize the cross-over by using participants in one community as the intervention group and participants in another as the control group. However, cross-over is still possible. It is difficult to determine the impact of this potential cross-over between groups.

Another limitation is that results of the M&E are not generalizable to other communities. Each town in which *Nica Agua* is implemented will have its own cultural and environmental factors impacting rates of diarrhea, making it difficult to apply the results of the M&E in one setting to any other setting. This poses a challenge to Comunidad Connect, since it implements programs in multiple parts of Nicaragua and the Dominican Republic. While the M&E results may not be generalizable across settings, the M&E designs can be easily adapted to other settings, allowing Comunidad Connect to determine the *Nica Agua's* impact in communities outside Los Robles.

Public Health Significance

This special studies project has the potential for both local and international public health significance. Locally, the monitoring and evaluation plans designed in this project may be used to determine if a BSF distribution program is an effective way to reduce diarrheal illness in rural northern Nicaragua. This helps to address the significant burden of disease caused by diarrheal illness.

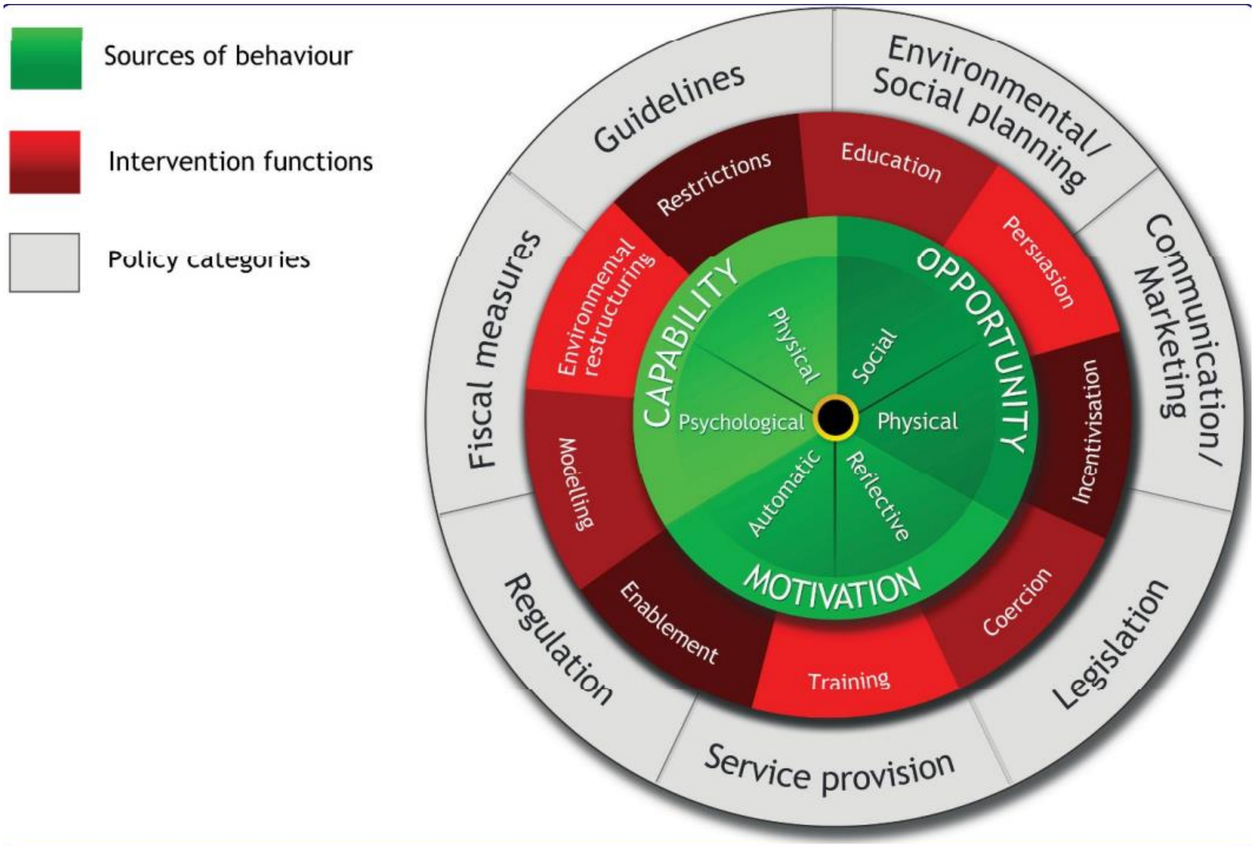
Aside from the local benefit, this project also has the potential for international public health significance. The M&E designs may be used as a framework that other organizations may adapt and implement in other settings. Additionally, with rigorous M&E, *Nica Agua* can contribute to the body of evidence for water filter distribution programs. This body of evidence provides the groundwork for other organizations to select effective interventions when combating diarrheal illness. Through adaptation of these M&E designs and contribution of the results to the water filter evidence-base, the M&E plans designed in this project have the potential for impact outside of Comunidad Connect.

Conclusion

This special studies project was developed to provide a framework for structured, rigorous monitoring and evaluation of Comunidad Connect's *Nica Agua.* Three M&E designs were created, each with varying levels of attributability, equality, logistical complexity, and resource requirements. After consideration of the strengths and limitations of each design in conjunction with the goals of Comunidad Connect, the plausibility design with a difference-in-difference evaluation is likely the most fitting option for *Nica Agua*. However, the program staff must choose which design they find most fitting for the program's needs before beginning the initial preparations for *Nica Agua*. Program staff must also be aware that while steps were taken in the creation of the M&E designs to minimize limitations, there are still some notable limitations to this special studies project. Despite such limitations, this project has the potential for local impact in northern Nicaragua. It also has the potential for more extensive impact through contributing to evidence-based practice for combating diarrheal illness.

Appendices

Appendix A



The Behavior Change Wheel (Michie et al., 2011)

Appendix B: Timelines

3 Phases:												
Baseline				**Phase 1**				**Phase 2**				**Phase 3 (Evaluation)**
January	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**January**
Baseline Interview	Community service hours and educational talks	Community service hours and educational talks	Community service hours and educational talks	Filter delivery	Monthly Home visit	Monthly Home visit	Monthly Home visit	Monthly Home visit and review of past 4 home visits	Monthly Home visit	Monthly Home visit	Monthly Home visit	Delivery to final group, follow-up interview and evaluation
4 phases:												
Baseline			**Phase 1**			**Phase 2**			**Phase 3**			**Phase 4 (Evaluation)**
January	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**January**
Baseline Interview	Community service hours and educational talks	Community service hours and educational talks	Filter delivery	Monthly Home visit	Monthly Home visit	Monthly Home visit and review of past 3 home visits	Monthly Home visit	Monthly Home visit	Monthly Home visit and review of past 3 home	Monthly Home visit	Monthly Home visit	Delivery to final group, follow-up interview and evaluation
6 phases:												
Baseline		**Phase 1**		**Phase 2**		**Phase 3**		**Phase 4**		**Phase 5**		**Phase 6 (Evaluation)**
January	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**January**
Baseline Interview	Community service hours and educational talks	Filter delivery	Monthly Home visit	Monthly Home visit and review of past 2	Monthly Home visit	Monthly Home visit and review of past 2 home	Monthly Home visit	Monthly Home visit and review of past 2 home	Monthly Home visit	Monthly Home visit and review of past 2 home visits	Monthly Home visit	Delivery to final group, follow-up interview and evaluation

Three options for the stepped-wedge timeline used in the probability design

Appendix C: Baseline/Follow-up Questionnaire

Comunidad Connect
Nica Agua
Baseline or Follow-up Visit (circle one)

NICA AGUA

General data. *Write the response to each question, including responses such as "no," "zero," and "never"*

County: _________________ Community: __________________ Address: _______________________________________

Participant ID: ________________ Filter: ______ Control group: Si ___ No ___ Cierre etapa #____

Date: ____/ ____ / ____ (DD/MM/YYYY) Date filter was delivered: ____/ ____ / ____ (DD/MM/YYYY)

Full name of participant (How is it spelled?): ____
Full name of participant (How is it spelled?): ____ Age: ___ Telephone #: _____________

Household information

1) Total # of people in the home: ________

2) Total # of families in the home : ______

3. Personal data of household members (May write more names below tables if necessary):

Person	Age	Sex	Mark with an X if person is pregnant	Working or studying (choose one)?
1				
2				
3				
4				
5				
6				

Person	Age	Sex	Mark with an X if person is pregnant	Working or studying (choose one)?
7				
8				
9				
10				
11				
12				

Question	Response	Explanation of response or observation of interviewer
4. Do you have a human waste disposal method (bathroom, latrine, other)?	**Yes ( ) No ( )**	
5. If so, what type?	**Toilet ( ) Latrine ( ) Composting latrine ( )** **N/A ( ) Other: ____________________**	
6. What is the main way in which you dispose of your trash?	**Burn pile ( ) Burry ( ) Collection service ( )** **Dump it elsewhere ( )** **Other: ____________________**	
7. How do you dispose of waste	**In the street ( ) In the yard( ) Sewer( ) septic**	

water (laundry water, handwashing water)?	**tank(Other: ______________**	
8. Observed sanitary condition of the house (circle one)	**1 (very dirty) 2 3 4 5 (very clean)**	

Analysis: Only applies to families with the filter.

Question	**Response**	**Explanation of response or observation of interviewer**
9. Are you currently using the filter?	**Yes ( ) No ( )** How long ago did you stop using it?	
10. Have you had problems using the filter?	**Yes ( ) No ( )**	
11. How beneficial do you think the filter is for the health of you and your family?	**1 (Not beneficial) 2 3 4 5 (very beneficial)**	
12. How often do you maintain your filter?	Every week ( ) 3 times/month ( ) 2 times/month ( ) Once/month ( ) Other: ____________________	
13. How do you maintain your filter?	Explain:	
14. *Observe the physical state of the filter and mark all relevant answers*	Intact( ) Broken( ) Clean( ) dirty( ) Not functioning( )	
15. *Observe the physical state of the collecting bucket and mark all relevant answers*	Intact( ) Broken( ) Clean( ) dirty( ) Not functioning( )	

16. *Observe the physical state of the spout and mark all relevant answers*	Intact( ) Broken( ) Clean( ) dirty( ) Not functioning( )	
17. *Observe: is there water in the filter?*	Yes ( ) No ( )	
18. Does the whole family only consume water from the filter?	Yes ( ) No ( )	
19. If not, who doesn't consume filtered water?	Mother ( ) Father ( ) Grandparents ( ) Children( ) Other:_____________________	
20. Do you believe the filter has improved the health of your family?	Yes ( ) No ( ) Somewhat ( )	
21. How have you felt different since drinking filtered water?	Explain:	

Health Data: Applies to all participants.

Question	**Response**	**Explanation of response or observation of interviewer**
22. From what primary source do you get the water you consume?	Water Well ( ) Watering hole ( ) River ( ) Piped water ( ) Store-bought water ( ) Other: ___________	
23. Do you treat water when it isn't filtered	Yes ( ) No ( )	
24. If so, how do you treat it?	Boil( ) Chloring( ) Solar/SODIS ( ) Other__________	

25. When did you last take anti-parasite medication?	<1month ( ) 1-3 months ( ) 3-6 months ( ) 6-12 months ( ) More ( ) Never ( )	
26. Who in the house took anti-parasite medication then?	Mother ( ) Father ( ) Grandparents ( ) Children( ) Other:____________________	
27. Do you buy bottled water?	Yes ( ) No ( )	
28. If so, how many bottles per week?	1 ( ) 2 ( ) 3 ( ) More: _____	
29. How much does each bottle cost you on average?	Cost per bottle: ______	

30. **All families:** Should fill in for people in the house with 1+ episode of diarrhea in the past 7 days. Ask each adult in the house if possible. Adults may answer for children.

Read: "Diarrhoea is defined as the passage of three or more loose or liquid stools per day (or more frequent passage than is normal for the individual). Frequent passing of formed stools is not diarrhoea, nor is the passing of loose, "pasty" stools by breastfed babies.." The end of a case of diarrhea is when the person does not pass loose or liquid stools three or more times in 24hrs, or with greater frequency than is normal for the person.

Person's number (Use the same # as seen in the table in section 3-Personal data of household members)	**Days with diarrea with and without medical attention**	**# of days of diarrhea in the last 7 days**	**Type of treatment** Fluids= F Anti-parasitic= P Natural medicine= NM None=0	**Where did you receive treatment?** Health center = HC Pharmacy = PH Brigadista = B	**Cost of treatment (C$)**	**Cost of medical transport (C$)**	**Number of missed days at work/school** Work / School	**Approximate income lost due to missed work**

	With medical attention								
	Without medical attention								
	With medical attention								
	Without medical attention								
	With medical attention								
	Without medical attention								
	With medical attention								
	Without medical attention								

31. The filter has a lifespan of 2.5yrs. Would you be willing to buy another filter to replace it? Yes _____ No _____ Why? ____

32. ¿Would you be willing to buy a part of the filter if a part breaks? Yes_____ No _____

33. What do you think of the *Nica* Agua program? Any recommendations for the program?

____

____

________________________________ ____________________________________

Name of interviewer Name of the interviewed

Thank you for your time

Recorded in the computer? ___

Appendix D: Home Visits

Home Visit *Nica Agua*

Date: _________ Participant ID___________

Observe the conditions of the filter and home. Remind the family of the importance of appropriate use and maintenance of the filter if applicable.

Water	Household Hygiene	Food Hygiene	Hand Hygiene	Sanitation
Visit #1 **Date:** ______ **Question:** Have you used the filter in the last 24hrs? Yes__ No __ Exclusively drinking filtered water can prevent which of the following? Common Cold__ Diarrheal illness__ Parasitic infection__ Tetanus__ Syphilis__ **Observe:** Does the filter appear to be in use? Yes__ No __ Does it contain water? Yes__ No __	**Observe:** Do floors appear swept? Yes__ No __ No animals indoors? Yes__ No __ No animal feces? Yes__ No __ No uncovered food left out? Yes__ No __ No or few flies? Yes__ No __	**Ask:** In the last 24hrs, have you used filtered water: To wash fruits and vegetables? Yes__ No __ To make drinks, popcicles, or ice? Yes__ No __ In all raw foods? Yes__ No __	**Ask:** When do you wash your hands? (Don't tell them the options): After using the bathroom__ After touching raw meat__ Before cooking__ Before eating__ **Observe:** Please show me how you wash your hands. Water__ Soap__ Both hands__ Washes hands 20+ seconds__ Dries hands with a clean towel or air dries__	**Ask:** Do you have regular access to sanitary services? For example, a toilet or latrine of your own or a neighbor's you use normally? Yes__ No __ In the last 48hrs, have you only used a toilet or latrine? Yes__ No __

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