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Evaluation of a Community-Wide Water Store Intervention in Rural Guatemala

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An abstract of
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Abstract

Evaluation of a Community-Wide Water Store Intervention in Rural Guatemala
by Katelyn Lengacher

Objectives: In 2018, Healing Waters International installed water purification systems in two rural Guatemala communities, Sesajab and Socoyou. This thesis presents an evaluation of the effectiveness of those water purification systems in reducing the number of diarrheal episodes, the number of school days missed, and the number of liters of soda purchased.

Methods: Baseline household surveys (n=145) were collected in each community in September 2018 and post-intervention surveys (n=160) were collected from water store customers and noncustomers in March 2019. Analysis methods included chi-square analysis between several variables collected in the surveys, logistic regression modeling for the outcome variables, and qualitative analysis from the customer surveys.

Results: There were trends in the baseline and post-intervention data, showing that there were decreases in the number of diarrheal episodes, number of school days missed, and number of liters of soda purchased by households. At baseline in both communities, households reporting one or more diarrheal episodes were more likely to miss school than households not reporting diarrheal episodes. For the Sesajab community alone, purchasing soda was also found to be a predictor of diarrheal episodes in the baseline households ($OR=5.6$, $p<0.05$). Among the post-intervention surveys from Sesajab, customers who drank from the water store were less likely to purchase soda ($OR=0.275$, $p<0.05$). Qualitative data also showed a positive impact from the water store on the communities, with households reporting greater convenience obtaining water and improved health because of the new water source.

Conclusion: Due to a lack of comparable samples between baseline and post-intervention results, analyses were limited and actual impact of the water store was difficult to assess. When looking at the number of diarrheal episodes, number of school days missed, and the number of liters of soda purchased, all three outcomes decreased over the course of the study period. However, it was unclear if the decreases seen between the two groups were due to the water store intervention.

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Introduction

Global Water Crisis

There is currently a global water crisis, as millions of people worldwide still do not have access to this basic human right.(1) An estimated 844 million people worldwide, approximately 1 in 9, do not have access to clean, safe water.(2) The water crisis is not only leading to disparities in access to safe water, but it also has ripple effects on health, women and children, and economies. In developing countries, approximately 80% of illnesses are linked to poor water and sanitation conditions while one out of every five deaths under the age of five is due to a water-related disease.(3) This suggests that ending the global water crisis would make healthier communities and reduce mortality rates worldwide. In addition to a health crisis, women and girls spend approximately 200 million hours each day collecting water. The responsibility to find and obtain clean water often falls on women and girls' shoulders, which takes time away from work, school, and caring for their family.(2) The water crisis extends to an education crisis when children are responsible for collecting water, leading to them missing school in order to obtain this needed resource. One third of all schools also lack access to basic water and sanitation which further impairs the children when they are trying to learn. Lastly, the water crisis is also an economic crisis as time spent gathering water takes away time away from economic opportunities, leading to approximately $260 billion dollars lost globally each year due to the lack of these basic services.(2)

While the large numbers of people affected by the global water crisis can seem overwhelming, what it tangibly means is that there are communities and individuals who struggle every day with knowing where their water will come from or knowing that drinking the water available to them will make them sick. It is mothers waking up, stressing because they have to walk hours to get water that will only make their children sick. It is children not knowing what it is like to have reliable and safe water flow out of a faucet, deficits that cause them to fall behind in school and have a harder time escaping the cycle of poverty. However, safe drinking water is not only about water quality, quantity, and accessibility. It is also about peoples' socio-cultural beliefs, practices, behaviors, and perceptions. Research has shown that water issues are often gendered and its use is often categorized by social and cultural norms.(4) Therefore, it is important to remember that drinking water is simultaneously linked to human behavior and these social, behavioral, and cultural aspects need to be included when thinking about drinking water.(5) For decades, organizations, governments, and individuals have been working to figure out a solution to end the global water crisis. Different water solutions, such as boreholes, hand dug wells, and piped water systems, have all been proposed and executed. While different systems have different success rates, the world's water crisis can unfortunately not be solved with a "one size fits all" mentality. While solutions are still being tested, communities are left in the balance, having to drink from heavily contaminated, inconvenient, and unreliable water sources. This creates the pressing need for

non-profit organizations, communities, and governments to work together to create effective, efficient, and reliable solutions for the billions of individuals still lacking access to clean water.

Healing Waters International

Healing Waters International (HWI) is a non-profit organization with the mission of ending the global water crisis by building holistic clean water solutions in at-risk communities around the world.(6) To do this, they primarily work in four countries: Guatemala, Haiti, Mexico, and the Dominican Republic. For this specific evaluation, HWI partnered with another non-profit organization, Mercy Corps, to provide clean water systems to two rural Guatemalan communities located in the Alta Verapaz department. The goal of this study was to evaluate the effectiveness of this clean water intervention on the communities, specifically examining the outcomes of diarrheal episodes reported, number of households purchasing soda on a weekly basis, and number of school days missed for households with children. Before looking at the specific Guatemalan communities, it is important to know what has already been done and is established within the water, sanitation, and hygiene (WASH) field.

Literature Review

Sustainable Development Goals

In September 2000, the Joint Monitoring Programme for Water Supply, Sanitation, and Hygiene (JMP) enacted eight goals and twenty-one targets known as the Millennium Development Goals (MGDs). These eight goals focused on eradicating extreme poverty, achieving universal primary education, promoting gender equality, reducing child mortality, improving maternal health, combating diseases, ensuring environmental stability, and developing global partnership.(7) The MDGs were the first of their kind in creating a global priority on improving poverty, education, and overall health. Additionally, the MDGs helped in creating and improving county data systems and monitoring. The JMP is responsible for tracking progress towards these goals and has been creating updates on the progress since the beginning of the MDGs in 2000.

Overall, the MDGs did not end without leaving behind substantial improvements and advancements. The number of deaths of children under five years of age dropped from 12.7 million in 1990 to 6.3 million in 2013, new HIV infections declined by 38% between 2001 and 2013, and the percentage of underweight children under five years of age dropped from 28% in 1990 to 17% in 2013.(8) By 2015, seven out of ten people used safely managed drinking water services.(9) According to the JMP, safely managed drinking water refers to drinking water sources that are located on premise, available when needed, and free from fecal and chemical contamination. Basic water sources refer to

improved water sources that include a collection time of less than 30 minutes while limited water sources refer to improved water sources where collection time exceeds 30 minutes. Unimproved water sources refer to drinking water from an unprotected well or spring.(9)

Despite the coverage obtained, the inequalities in service between urban and rural, rich and poor, and other groups and the general population has become more widespread. The MDGs tended to focus on aggregate targets and indicators for countries which led to inequalities in services provided to people within a country. Uneven progress for the poorest and hardest to reach areas and populations was one of the downfalls of the MDGs.(7) Because of this, the SDGs have a stronger focus on inequalities and are guided by principles of human rights, gender equality, empowerment, and sustainable development.

The MDGs were replaced with the Sustainable Development Goals (SDGs) in 2015. The transition consisted of a global collaboration and conversation leading to the creation of seventeen goals and 169 targets. While the MDGs did not include a target focused specifically on WASH, goal six of the SDGs is focused solely on ensuring "availability and sustainable management of water and sanitation for all".(9) The first target of the goal aims to achieve universal and equitable access to safe and affordable drinking water for all, showing the move to reduce inequalities between those receiving services and those not gaining access.(9) The SDGs also focused on creating indicators that will report on these inequalities by disaggregating them by place of residence,

socioeconomic status, inequality, and service level. These indicators will hopefully increase the monitoring efforts of countries and aid in the achievement of the SDGs by 2030.

Drinking Water Status and Challenges - Globally

According to the JMP Progress Report on WASH, the proportion of the population with at least basic drinking water services has increased by an average of 0.49% between 2000 and 2015. Additionally, Latin America is on track to achieve universal basic drinking water services by 2030.(9) Globally, 71% of the population used a safely managed drinking water service with eight out of ten people using an improved water source with water available where needed, three out of four people using an improved source that was located on premises, and three out of four people using an improved water source that was free from contamination.(9) While these estimates are encouraging, there is still an issue of ensuring that all drinking water is clean and safe to drink. It is estimated that nearly 25% of the population is drinking water that has been contaminated by feces, which lead to disease and can lead to death.(10) It is also known that despite the advances in access to clean water, the disparities for rural, low-income communities in developing countries still remains large.

Not only are water issues an issue of access, development, energy and available resources, they are also a human rights issue.(11) It was only in 2010 that the United Nations General Assembly declared the access to water and

sanitation a human right. The problem is that while water is a necessity of life, it is also a finite resource that entails cost.(12) Because of these complex intersections, there are several challenges to improving drinking water globally. First, water distribution system vulnerability has increased as the standards of living has risen and water infrastructures have aged. These vulnerabilities can lead to contamination of water sources widely used by populations, both in urban and rural areas. While the proportion of waterborne disease outbreaks in the United States has decreased since 1980, the same cannot be said when it comes to waterborne disease outbreaks in distribution systems.(12) These issues in the distribution systems are magnified in middle income and developing countries as they not only lack the resources needed to repair and maintain the systems, but they also lack the financial resources to enact these necessary changes. These aging water systems are a barrier to achieving water access for all and will require great financial and economic resources in order to ensure distribution systems are delivering clean, safe water to communities.

Second, water scarcity is a problem affecting the ability to provide water for all by 2030. While global water sources are abundant, only 2% of the entire supply is salt-free and only 1/3 of that salt-free supply is available for human use.(13) In the past 50 years, global water use has risen due to population growth and increased agricultural demands and uses. Water scarcity not only affects humans, but it also threatens agricultural production and political stability. Agricultural production requires large amounts of water, and an estimated 70%

of the world's water supply is used for irrigation.(12) With the growing global population rates, food consumption will only continue to increase leading to greater demands on water used for various agricultural needs. Water scarcity also threatens political stability. The International Water Management Institute predicts that 1.8 billion people will live in areas facing physical water scarcity, meaning water for food production, drinking, cooking, and hygiene needs will be diminished. Additionally, countries can also be classified as economically water scarce, meaning they have sufficient water sources to meet their needs but they lack the financial resources in order to improve water development projects.(12)

Lastly, the consequences of climate change are expected to have an impact on the global water supply. With rising air temperatures, evaporation rates increase which could lead to reduced runoff.(14) This reduced runoff could potentially lead to a reduction in renewable water supplies. This could also lead to water quality problems as there is less water flow to dilute contaminates that enter the water supply from natural and human sources.(14) However, it is also possible that increased precipitation due to higher evaporation rates could lead to more annual runoff. In this case, higher amounts of contaminants will enter the water source and stress the system's ability to effectively treat and disinfect the water. The frequency and severity of droughts is also predicted to increase as a result of decreased rainfall, more frequent dry spells, and higher evaporation rates.(14) This is especially important when considering the wet and dry seasons

many developing countries experience. Water quality is understood to be worse during wet seasons which implies that fecal contamination is greater during those seasons.(15) Fecal contamination was also found to be stronger during wet seasons for rural areas versus urban settings.(15) This shows the importance of considering the variation in fecal contamination levels during different seasons and in different population settings and ensuring data collection is done in differing seasons to accurately quantify and describe contamination through both the wet and dry months. Fecal contamination is not always seen as a seasonal variable, however, it should be considered as such and expected to be more frequent during periods of large rainfall. While the full consequences of climate change are unknown, it is expected to have an effect on the global water supply and create a challenge in bringing safe, clean water to all by 2030.

Health Burden of Poor Water – Globally

It is well known that poor water and sanitation is linked with diarrheal diseases and that inadequate WASH is an important risk factor, especially in low-income settings. Improving global access to clean drinking water and safe sanitation has also been shown as one of the least expensive and most effective means to improving public health and saving lives.(16) In an analysis of the burden of diseases from inadequate WASH in low- and middle-income countries, it was estimated that over 500,000 diarrheal deaths were caused by inadequate drinking water and 280,000 deaths by inadequate sanitation.(17) In

total, 842,000 diarrheal deaths were estimated to be caused by these risk factors which accounted for 1.5% of the total disease burden. While significant improvements have happened in the WASH sector, the most current Global Burden of Disease study shows that diarrheal diseases were responsible for 2.81% of deaths in all ages and were specifically responsible for 9.9% of deaths in children under the age of 5.(18)

One reason that improved WASH results in decreased diarrheal diseases is that it serves as important barriers in the various routes of pathogen exposure. Fecal-oral transmission routes refers to the movement of pathogens from the feces of humans and animals to another person through five common routes: food, fingers, flies, fluids, and fields.(19) Through these transmission routes, feces from animals or humans are able to come in contact with individual's fingers by way of fields, by way of flies landing on feces and then landing on household surfaces, and by way of contaminated fluids. Additionally, food can become contaminated through direct contact with human and animal feces or by the handling of food by contaminated individuals' hands. While there are many different transmission routes, differing WASH practices are able to block fecal transmission for every possible route.(19) By targeting water interventions that improve the quality and safety of water, transmission due to contaminated water can be decreased leading to less diarrheal diseases. Clean, safe water is also needed for hygiene purposes which further block the routes of fecal contamination via fingers, food, and flies. While considering the health burden of

poor water, it is also important to consider the negative effects of sugary soda drinks.

There are several health consequences that can result from large amounts of soda consumption. Studies have shown that excessive sugar intake from soft drinks play a major role in the rising rates of obesity around the world.(20) Not only do higher obesity rates have negative consequences on children's physical health, but it also affects their self-esteem, social and emotional well-being, and can lead to poor academic performances. Studies have shown that overweight children were more likely to miss school because of chronic health conditions, which ultimately affects their academic performance.(20) Soda consumption has also been negatively associated with achieving proper nutrients, such as vitamin A, calcium, and magnesium.(21) Additionally, research has shown that children with stunted growth and frequent diarrheal episodes are at an increased risk of developing obesity, which results in a "triple burden" of diarrhea, stunting, and chronic disease.(22) While sugary drinks are more often linked to obesity, these topics are closely intertwined with WASH, as the creation and promotion of clean water sources will give healthier options for households to drink water instead of soda. With the provision of clean water sources in a community, households will have the chance to make healthier choices which can influence school attendance, food choices, and the overall health of the community.

Drinking Water Status and Challenges – Guatemala

The current population of Guatemala exceeds 16 million individuals and has a population growth rate of 1.72%.(23) It is the most populous country in Central America, and also holds some of the highest infant mortality rates in Central America.(24) The majority of the population lives in the southern, mountainous regions with more than half of the population living in rural areas. Additionally, 42% of the population belongs to an indigenous group which constitutes some of the highest indigenous group populations in Latin America.(24) The country of Guatemala is divided into 22 different departments, which include a capital and are further divided into municipalities. There are five departments that remain below the MDG target for access to improved drinking water: Alta Verapaz, Chiquimula, El Progreso, Petén, and Santa Rosa. While Guatemala boasts a large economy in Central America, the levels of inequality are great within the country and lead to many differing levels of service and access to basic needs.(24) The majority of Central and Latin America has experienced declining poverty rates from 2000 to 2014; however, Guatemala experienced a rise from 55% to 60% during the same time period.(24) Poor individuals are also grouped together in rural areas and among indigenous people groups. In Guatemala, it has been shown that the poor are more likely to live in rural areas, to belong to an indigenous group, and to have low levels of education.(24) While this is not uncommon for other low-income and developing countries, Guatemala's main issue stands in the way of the large gap of

inequalities between different groups throughout the country. It is said that Guatemala has "two Guatemalas", one of which includes the few rich people and one that has the rest of the poor individuals. This picture of two Guatemalas accurately describes the need to work towards bringing clean water to the underprivileged areas in order to decrease the gap of inequality.

Nationally, 91% of the population has access to improved drinking water.(25) This increased from 77% at the beginning of the MDGs; however, this percentage has remained constant over the past several years instead of continuing to increase coverage in rural and underprivileged areas.(24) Since 2000, national drinking water coverage due to water being piped into a dwelling has increased from 67% to 75% while the lack of access to an improved water supply has decreased from 12% to 9%.(24) Overall, this shows that improvements have been made since the MDGs were first enacted. For example, the gap in access to an improved drinking water source between departments with the highest and lowest rates in the country went from 50% in 2000 to 17% in 2014. Alta Verapaz, one of the most underserved and poorest departments, also saw an increase in access to an improved water source. However, it remains the department with the lowest access to improved water.(25) Studies have also shown that differences in access to improved water sources along socio-economic lines are due to age, education, employment sector, and ethnicity.(25) These findings have profound impacts on Alta Verapaz as it is a poorer department with lower socioeconomic status which creates challenges in

accessing improved water sources. The sprint to meet the MDGs helped gain water access for certain areas and began the needed work to bring water to underprivileged departments; however, the work has since halted and more changes and improvements are needed in order to achieve SDG goals of availability and sustainable management of water for all.

One of the main challenges facing Guatemala's drinking water supply is the ability to successfully manage its national water resources.(26) Guatemala has an ample amount of rainwater, surface water and groundwater throughout the region's three hydrographic regions. However, these sources are subject to contamination, seasonal changes, and unequal distribution which contribute to the overall water challenges in the country. Additionally, the pattern of water sources and population density are at odds. For example, the Pacific Ocean Basin is the least hydrologically rich of the three hydrographic regions and only covers 22% of the country, but holds some of the most populous departments in its region.(24) With changing climates and weather patterns, it is imperative that new resources and infrastructure be available in order to decrease the threat of water scarcity within the country. Guatemala also has considerable water inequalities between the 22 different departments. In the department of Alta Verapaz, 81% of people have access to an improved drinking water source, but only 41% benefit from a piped water supply to their household, indicating that high percentages of households rely on untreated surface water as their main water source.(24) This further leads to the disparity of this department in gaining

equal and complete coverage and access to improved drinking water. The region is also home to a large number of indigenous people which have been shown to be at a disadvantage in gaining access to improved water throughout Guatemala.

Health Burden of Poor Water – Guatemala

The leading causes of death in Guatemalan children under five years of age is acute respiratory infections (ARIs), making up 34% of all deaths. The next highest cause of death is diarrheal diseases, which constitute 18% of all deaths in children of the same age group.(24) Along with ARIs and diarrheal diseases, rates of chronic malnutrition and stunting in Guatemala children are among the worst in the world.(27) Lack of clean water and poor WASH infrastructure are main contributors to these health outcomes and have led to almost half of the children in Guatemala being chronically malnourished.(27) The high incidence of diarrhea in the indigenous populations of Guatemala has also been directly linked to poor water quality and sanitation.(28) In rural areas that lack access to clean, safe water, poor health outcomes constitute a major public health problem as the underserved populations do not have the same access to care or resources as more urban areas. Since a large percentage of households are relying on surface water sources and contamination to surface water is common, lack of clean water can easily contribute to the transmission of these diseases.

Not only is chronic malnutrition attributed to a lack of food, but lack of access to clean water only worsens the issue. The populations affected most by

malnutrition are largely indigenous, rural populations that have lower rates of income, education, and access to needed resources.(29) Even if nutritional supplements are given, the underlying water contamination and limited sanitation solutions in many of the communities prevents the elimination of disease and malnutrition. At its roots, the issue of malnutrition is one of poverty and lack of awareness in the fact that stunting is an issue because the problem is so widespread in many communities throughout Guatemala.(29) Healthcare expenditure is also an issue in Guatemala. As of 2011, the per capita GDP of Guatemala was US$2,303.90, 6.9% of which was spent on healthcare.(28) This makes Guatemala one of the countries with the lowest expenditure on health. Additionally, health resources are concentrated in the urban areas while the majority of the population lives in rural locations, further leading to disparities in access to healthcare.(28) While the negative consequences of poor water are widespread in Guatemala, communities and organizations are working to change this narrative.

Communities in Need – HWI Solutions

There are many organizations working to find solutions to end the global water crisis. HWI has created an approach centered on developing strategic partnerships with local community members and leaders through water purification systems, business training, and health and hygiene education programs for both children and women. HWI has created water purification

systems that are designed specifically for the local context of the community. Therefore, some systems will run on grid power or generators while other communities might receive a system run by solar power or gravity. As communities are identified for the placement of potential water filtration systems, HWI invests in the community members to teach, train, and empower their leadership and ownership of the water project. Locals are trained in the areas of system maintenance, health and hygiene education training, and business administration in order to ensure the sustainability and effectiveness of the interventions. Water stores are installed in the form of a community-appropriate water distribution store, including a sales model, that will produce income and profit to cover maintenance costs and employ individuals from the community.

Methods

Study Site

In 2018, HWI partnered with Mercy Corps, a global humanitarian aid organization, to bring water purification systems, water business and operations training, and health and hygiene education programs to five rural communities in Guatemala that lacked access to clean, safe water. Of these five communities, two were selected for further monitoring and evaluation, including baseline and post-intervention surveys of both customers and noncustomers. These communities were selected based on convenience to receive further monitoring

and evaluation. The two selected communities, Sesajab and Socoyou, are both located in the Guatemalan district of Alta Verapaz (Figure 1). The population of Alta Verapaz was estimated to be approximately 1.1 million in 2012.(30) Alta Verapaz is home to some of the most extreme poverty rates in Guatemala and has the lowest percentage of households with access to improved water.(25) These study sites were identified because of their rural setting and need for a reliable water source in the community. Photos are included which show the completed water store along with the inauguration of the water store in Sesajab (Figure 2).

Figure 1. Map of departments in Guatemala, with Alta Verapaz department in yellow near center of map. Both study sites, Socoyou and Sesajab, are located near Cobán, the capital of Alta Verapaz.
Source: *https://geology.com/world/guatemala-satellite-image.shtml*

Figure 2. Photo of the completed water store (left) and the water purification system installed in the Sesajab community (top right). Photo of the inauguration of the water store in Sesajab with the community members in attendance (bottom right).

Survey Methods

Survey questions were created by HWI as part of their impact monitoring and evaluation plan, which includes following the communities for three years after the installation of a water store in order to assess the full impacts on the community. Baseline surveys are collected before the project is inaugurated and

then customer and noncustomer surveys are collected 3 months, 1 year, 2 years, and 3 years after implementation of the water store. Surveys were created by HWI using a survey app, mWater. Field staff in Guatemala were in charge of training local surveyors who are familiar with the community members and able to receive honest answers from households taking the survey. Surveyors used a digital phone or tablet with the downloaded survey, thus making internet connection not necessary for the data collection portion of the surveys. Baseline surveys were collected in September 2018 and post-intervention surveys were collected the following March. It is important to note that the baseline surveys were collected during Guatemala's rainy season, which runs from May to October, while the post-intervention surveys were collected in the dry season. For the surveys, the unit of analysis is one household with one survey respondent per family. Surveys were collected by walking door-to-door in the community within a walkable radius of approximately 0.5 kilometers from the water store. Thus, this determined who was eligible to take the survey and created the population of baseline surveys. Once surveys were collected, the data was uploaded when the surveyor reached a location with internet connection. Results were then uploaded to HWI's data portal, mWater, for further evaluation and analysis. The post-intervention customer surveys included qualitative data questions, asking about the impact of the water store on the customer's family. However, this question was randomly asked to a quarter of the respondents so only ten customer households in each community answered the question. While

qualitative focus groups are a part of the impact evaluation process, these data were not yet collected for this project due to time constraints.

Data Analysis

All data analysis was performed in SAS version 9.4. Data cleaning involved dichotomizing variables, such as diarrheal episodes, soda purchases, and school days missed, in order to create outcome variables that could be analyzed using logistic regression. Additionally, dichotomous variables were preferred as there was large variance in the responses for many variables, therefore, dichotomizing the variables allowed for greater statistical power when analyzing. Descriptive statistics were run on each type of survey: baseline households, post-intervention customers, and post-intervention noncustomers. Chi-square analyses were run to identify any significant differences between the dichotomous outcome variables of diarrheal episodes, soda purchased, and school days missed and other possible variables, such as occupation, drinking source, and city. Overall trends in baseline data were compared to trends in the post-intervention data. However, direct comparison between the two sample types was limited due to the lack of comparable samples between the types of surveys. Logistic regression was run for the baseline data, assessing various predictors for school days missed and diarrheal diseases, and for the post-intervention data, assessing the outcome variable of households purchasing soda while comparing customers to noncustomers.

Results

Sesajab Baseline Results

Table 1 shows data collected from 65 household baseline surveys in the Sesajab community. Overall, these data show a community where the majority of the households worked as domestic employees and used a well as their main drinking water source. The majority of the households (n=37, 57%) reported that they chose their drinking water source first because of the cost and then because of the location/availability of the source. The mean number of people in a household was 4.88 (SD=1.86) and the mean number of school-aged children in each household was 1.48 (SD=1.31). Of the 37 households with school aged children, 13 (35%) reported missing school in the last month due to an illness. The data also showed that 68% of the households reported purchasing one or more liters of soda per week and 63% of the households experienced one or more diarrheal episodes in the last week.

Socoyou Baseline Results

Table 1 shows data collected from 80 household baseline surveys in the Socoyou community. Overall, these data reveal a community where 98% of the heads of households were farmers and 96% of households reported using surface water (spring, lake, or river) as their main drinking water source. While this community used a different source for their drinking water, the majority (n=59, 74%) reported the same reasons for choosing this water source: cost first and then

location/availability. The mean number of people in a household was 4.41 (SD=2.43) while the mean number of school-aged children was 1.31 (SD=1.53). Of the 33 households with school-aged children, 26 (79%) reported having missed one or more days of school in the last month due to diarrheal illness. The data also showed that 100% of the households reported purchasing one or more liters of soda in the past week and 85% of the households reported having one or more diarrheal episodes in the last week.

Table 1. Descriptive Statistics from Baseline Surveys and Post-Intervention Surveys[1]

	Baseline			*Post-Intervention*		
	Sesajab	Socoyou	Overall	Sesajab	Socoyou	Overall
Total Number of Surveys	65	80	145	80	80	160
Number of Households with Children	37	33	70	57	49	106
Number of Customer Surveys	--	--	--	41	40	81
Number of Noncustomer Surveys	--	--	--	39	40	79
Number in Household, mean (SD)	4.88 (1.86)	4.41 (2.43)	4.62 (2.20)	4.7 (2.11)	5.47 (2.31)	5.08 (2.24)
Number of Children in Household, mean (SD)	1.48 (1.31)	1.31 (1.53)	1.39 (1.43)	2.29 (1.69)	1.89 (1.52)	2.09 (1.61)
Occupation, total (%)						
Farmer	17 (26%)	78 (98%)	95 (65%)	76 (95%)	73 (91%)	149 (93%)
Domestic Employee	48 (74%)	1 (1%)	49 (34%)	--	--	--
Professional	--	1 (1%)	1 (1%)	--	2 (3%)	2 (1%)
Local Shop Owner	--	--	--	4 (5%)	5 (6%)	9 (6%)
Drinking Source, total (%)						
Rain Catchment	2 (3%)	2 (3%)	4 (3%)	1 (1%)	--	1 (1%)
Surface Water (Spring, Lake, or River)	4 (6%)	77 (96%)	81 (56%)	--	39 (49%)	39 (24%)
Well	59 (91%)	1 (1%)	60 (41%)	--	--	--
HWI Water Store	--	--	--	41 (51%)	40 (50%)	81 (51%)
Jugs				3 (4%)	1 (1%)	4 (2%)
Municipal Tap	--	--	--	35 (44%)	--	35 (22%)
[2]Number of Diarrheal Episodes, total	41	68	109	7	1	8
[3]Number of Households Purchasing Soda, total	44	80	124	22	33	55
[4]Number of School Days Missed, total	13	26	39	2	0	2

[1]Customer and noncustomer survey results combined for the post-intervention group

[2]Diarrheal episode constitutes one or more diarrheal episodes in the last week

[3]Number of households that purchased one or more liters of soda in the last week

[4]School days missed in the last month for households with school-aged children

Overall Baseline Results

The number of diarrheal episodes, soda consumption, and missing school were identified as important outcome variables that would help determine if the HWI water store was effective in creating healthier communities. Chi-square analyses of these variables showed several relationships that were significant. For example, there was a statistically significant relationship between an individual having one or more diarrheal episodes and their drinking water source (X^2=8.7531, p<0.01). There was also a statistically significant relationship between an individual having one or more diarrheal episodes and the head of the household's occupation (X^2=6.73, p<0.01). When looking at households with school-aged children that reported missing school, there was found to be a statistically significant relationship between missing school and the head of the household's occupation (X^2=10.88, p<0.01) and between missing school and drinking water source (X^2=13.03, p<0.001).

Table 2 shows several variables evaluated as predictors of missed school for each baseline community. Overall, these data show that diarrheal episodes were a significant predictor of children missing school from both communities. For example, households in the Sesajab community that reported diarrheal episodes were 13.58 times more likely to report missing school in the last week than households not reporting diarrheal episodes (95%CI=1.381, 133.381, p<0.05). Additionally, households in the Socoyou community that reported diarrheal episodes were 33.33 times more likely to report missing school in the last week

than households not reporting diarrheal episodes (95%CI=2.744, 404.838, p<0.01). Drinking source and occupation were also evaluated for the Sesajab community but were not found to be significant predictors of missing school. For the Socoyou community, drinking source and occupation were not evaluated because there was no variation in the data as almost all households were farmers that used surface water as their main water source.

Table 2. Predictors of Missed School in Baseline Data[1], Stratified by City

	Sesajab (n=37)			*Socoyou (n=33)*		
Variable	OR[2]	95% CI[3]	Sig.[4]	OR	95% CI	Sig.
Diarrhea	13.57	1.381, 133.381	*	33.33	2.744, 404.838	**
Drinking Source						
Surface Water	4.16	0.052, 332.056		--	--	--
Well (reference)	--	--	--	--	--	--
Occupation				--	--	--
Farmer	0.923	0.059, 14.447		--	--	--
Domestic Employee (reference)	--	--	--	--	--	--

[1]Dataset only contained households with school-aged children

[2]Odds Ratio

[3]Confidence Interval

[4]Significance: *p<0.05, **p<0.01

Table 3 shows several variables evaluated as predictors of diarrheal episodes in the baseline data from the Sesajab community. Overall, the data show that purchasing soda was found to be a significant predictor of developing diarrheal episodes for the Sesajab community, with households purchasing one

or more liters of soda 5.6 times more likely to develop one or more diarrheal episodes than households who did not purchase soda (95%CI=1.146, 27.370, p<0.05). Drinking source and occupation were evaluated but not found to be statistically significant. These explanatory variables were only assessed in the Sesajab community because of the lack of variation in these variables for the Socoyou community.

Table 3. Predictors of Diarrheal Episodes in Baseline Data, Sesajab-only[1]

Variable	OR[2]	95% CI[3]	Sig.[4]
Purchasing Soda	5.6	1.146, 27.370	*
Drinking Source			
Surface Water	0.5	0.013, 19.562	
Well (reference)	--	--	--
Occupation			
Farmer	0.5	0.036, 6.997	
Domestic Employee (reference)	--	--	--

[1]n=65

[2]Odds Ratio

[3]Confidence Interval

[4]Significance: *p<0.05

Post-Intervention Results: Sesajab community

Table 1 shows data collected from 80 household post-intervention surveys in the Sesajab community. Of all 80 surveys collected, 41 came from households that were regular HWI water store customers and 39 were from noncustomer households. The mean number of individuals in a household was 4.7 (SD=2.11) and the mean number of children under five years of age was 2.29 (SD=1.69). The

majority of the households reported farming as the main occupation (n=76, 95%) with the remaining households working as local shop owners (n=4, 5%). All 41 of the customer households reported drinking exclusively from the HWI water store. The majority of the noncustomer households reported using municipal tap as their main drinking water source (n=35, 44%) with a small number of households reporting the use of jugs (n=3, 4%) or rain catchment (n=1, 1%) for drinking water. Of the 57 households with children, two households reported children missing school due to diarrheal illness in the last week, with customer and noncustomer households each contributing to one of those reported school days missed. Overall, the Sesajab data showed seven households reporting one or more diarrheal episodes, with three customer households and four noncustomer households making up this total. Additionally, 22 households reported purchasing one or more liters of soda in the past week with seven customers and 15 noncustomers making up these totals.

Post-Intervention Results: Socoyou Community

Table 1 shows data collected from 80 household post-intervention surveys in the Socoyou community, with an equal split of customer and noncustomer households surveyed. The mean number of individuals in a household was 5.47 (SD=2.31) and the mean number of children under the age of five was 1.89 (SD=1.52). None of the 49 households with children reported missing any days of school due to diarrheal illnesses. Similar to the Sesajab community, the majority

of the households worked as farmers (n=73, 91%) with a small number of households working as professionals (n=2, 3%) or local shop owners (n=5, 6%). All customer households reported drinking water exclusively from the HWI water store, except for one farmer who reported that their household also uses surface water for washing because the water they buy is only used for drinking. Of the 40 noncustomer households, 39 (98%) reported using surface water as their main drinking source with the remaining household reporting jugs as their water source. Overall, 33 households reported purchasing one or more liters of soda in the past week with an almost equal split between customers (n=16) and noncustomers (n=17). Only one customer household reported one or more diarrheal episodes in the last week and no households from the Socoyou community reported any school days missed in the past week.

Table 4. Differences Between Customers (C) and Noncustomers (NC) in Post-intervention Surveys

	Sesajab		*Socoyou*		*Overall*	
	C	NC	C	NC	C	NC
[1]Number of Diarrheal Episodes, total	3	4	1	0	4	4
[2]Number of Households Purchasing Soda, total	7	15	16	17	23	32
[3]Number of School Days Missed, total	1	1	0	0	1	1

[1]Diarrheal episode constitutes one or more diarrheal episodes in the last week
[2]Households that purchased one or more liters of soda purchased in the last week
[3]School days missed in the last month for households with school-aged children

Overall Post-Intervention Results

Overall, there were not many differences between customers and noncustomers in the post-intervention results. Table 4 shows the differences in number of diarrheal episodes, households purchasing soda, and number of school days missed between customers and noncustomers, with the main difference being in the number of households purchasing one or more liters of soda each week. Because the number of diarrheal episodes and missed school days between customers and noncustomers were essentially the same, comparisons between the customers and noncustomers and the outcome variables were limited. However, the difference in the number of liters of soda purchased between customers and noncustomers in the Sesajab community did allow for further analysis.

Table 5 shows predictors of purchasing soda in the Sesajab community. Overall, drinking water from the HWI water store was found to be a significant predictor of households purchasing soda, with households drinking water exclusively from the HWI water store being 73% less likely to purchase soda than households that used municipal tap as their drinking source (OR=0.275, 95%CI=0.096, 0.787, $p<0.05$). Predictors of diarrheal disease and school days missed were not evaluated for the Sesajab community because of the lack of difference between customers and noncustomers. Additionally, predictors of all three outcome variables, diarrheal disease, households purchasing soda, and number of school days missed, were not able to be evaluated for the Socoyou

community because there was no difference between the customers and noncustomers in that community. Additionally, there was a lack of comparable groups between the baseline and post-intervention survey groups which made comparisons between the two difficult and unable to be correctly identified. For example, baseline results from Sesajab revealed a community that was mainly domestic employees, however, the post-intervention results from Sesajab showed a community that was almost exclusively farmers. Therefore, this lack of comparable samples made direct comparisons difficult.

Table 5. Predictors of Purchasing Soda in Post-Intervention Data, Sesajab-only

		Sesajab (n=80)	
Variable	OR[1]	95% CI[2]	Sig.[3]
Drinking Source			
HWI Water Store	0.275	0.096, 0.787	*
Municipal Tap (reference)	--	--	--

[1]Odds Ratio

[2]Confidence Interval

[3]Significance: *p<0.05

Discussion

Trends in Baseline Data

When looking at the baseline survey results alone, several variables were found to be predictors of missing school (Table 2). When looking at the Socoyou community alone, the odds of missing school were 33.33 times higher for

households who reported one or more episodes of diarrhea than households who did not report any diarrheal episodes (95% CI=2.744, 404.838, $p<0.01$). This means that children who have diarrhea are much less likely to go to school, which can have an effect on their ability to learn and play a role in the overall education problem that accompanies the global water crisis. It is established that rural areas are already at disadvantages and missed school days will only contribute to the disparities. While the data estimate was not precise, it does suggest a connection between water and school and illustrates importance on providing clean water to minimize school absenteeism.

When looking at the Sesajab community alone, the odds of missing school were 13.57 times higher for households who reported one or more episodes of diarrhea than households who did not report any diarrheal episodes (95% CI=1.381, 133.381, $p<0.05$). This is to be expected since children experiencing diarrheal are less likely to feel well enough to go to school, resulting in a higher number of school days missed. It was also found that the odds of missing school among households who drank from surface water trended higher than households who drank from a well (OR=4.16, 95%CI=0.052, 332.056). Additionally, the odds of farmers from the Sesajab community missing school was almost 8% lower than households where the main occupation was a domestic employee, however, this result was also not significant. While both communities showed a connection between clean water and missing school, the estimate for the Socoyou community was significantly larger than the Sesajab

estimate. It is important to note that the majority of the Sesajab community households reported using wells as their main drinking water source. While wells are still susceptible to contamination, they are buried underground and usually covered which provides a source of protection against contamination. Therefore, it could be assumed that the estimate for the Sesajab community was lower than the Socoyou community because of the main drinking water source for the households. This finding could help inform intervention practices for HWI by focusing on families and households in Sesajab that are not using a well as their main water source and ensuring they know about the HWI water store and are using clean, safe water.

When looking at the predictors of having one or more diarrheal episodes in the Sesajab community alone, the odds of households who reported purchasing one or more liters of soda having diarrheal episodes was 5.6 times that of a household that did not purchase soda (95% CI=1.146, 27.370, $p<0.05$). Within this same group, occupation and drinking source were not found to be significant predictors of diarrheal episodes (Table 3). Diarrhea is often described as a result of contaminated water and food, therefore, this connection between diarrhea and soda is interesting. One explanation could be that sugar-sweetened beverages, such as soda, act as an osmotic diuretic. A higher solute concentration inside the bowel could result in higher levels of secretions of water from the body and ultimately create loose, watery stool. However, there are also studies showing that drinking soda substitutes drinking contaminated water which

would actually lead to a decrease in diarrhea prevalence coupled with an increase in obesity rates.(31) It is also important to note that the survey collected information on liters of soda purchased and not liters of soda consumed. While the exact pathway is not known, it can be concluded that households drinking more water and less sugary soda will experience greater health outcomes and result in healthier households and communities. Soda purchase and intake might not be a direct result of poor WASH infrastructure or practices in a community, however, it is a part of the larger picture of promoting healthy hygiene and nutritional practices and proves that it is necessary to invest in all parts of a community and not just solely one aspect of WASH.

Overall, there was low variability within the baseline data. The community of Socoyou consisted of 98% farmers, with 99% of those farmers obtaining their main drinking water from surface water. On the other hand, the community of Sesajab was 74% domestic employees that all reported their main source of drinking water coming from a well. Therefore, it was necessary to stratify the baseline data by community which consequently limited the analyses available due to high correlations within each site.

Trends Between Baseline and Post-Intervention Surveys

Overall, there were noticeable differences and trends in the data when comparing baseline survey results to post-intervention results (customers and noncustomers combined). When looking at the number of diarrheal episodes

reported by households, there were 109 overall episodes reported from the baseline surveys and eight overall episodes in the post-intervention surveys. There are noticeable differences in the number of diarrheal episodes between these two groups, however, when looking at breakdown of diarrheal episodes between customers and noncustomers in the post-intervention surveys, both groups had four households that reported diarrheal episodes in the last week (Table 4). This limited analyses because of the lack of difference between the customers and noncustomers, however, the differences in the number of diarrheal episodes between baseline and post-intervention surveys were noticeable.

When looking at the number of school days missed due to diarrheal illness, households from the baseline surveys reported a total of 39 school days missed and households from the post-intervention surveys reported two. However, both customers and noncustomers each had one household reporting one school day missed due to diarrheal illness which makes it difficult to credit the HWI water store intervention as the reason for this decrease in reported number of days as both customers drinking from the HWI water store and noncustomers drinking from a different water source had the same number of reported school days missed. It is also important to note that the two households who reported missing school were both from the Sesajab community, leaving no reported school days missed from the Socoyou community. Challenges arise when measuring diarrheal illnesses as it is a highly subjective measure that can

vary between households. It is important for HWI to be aware of this information because they might choose to measure this indicator in a different way other than just a survey question. For example, they could choose to compare attendance records from schools with the number of households reporting diarrheal episodes in children to see if there are large discrepancies. They could also shorten the recall time for reported number of diarrheal episodes or provide ways for the households to track the number of diarrheal episodes in the last week, which would eliminate recall bias and also lead to a more accurate number of diarrheal episodes in a community. Additionally, the large difference in the number of diarrheal episodes between baseline households and post-intervention households shows that there were factors that decreased the number of diarrheal episodes, however, the HWI water store intervention alone could not be credited for that reduction.

While diarrheal episodes and school days missed did not differ between customers and noncustomers in the post-intervention surveys, the number of households that purchased one or more liters of soda in the last week did show a difference between the two groups with 23 customer households purchasing one or more liters of soda in the past week and 32 noncustomer households reporting the same. The difference between customers and noncustomers for this variable allowed for further analysis.

Soda Consumption in Sesajab

When the Sesajab community was looked at alone, it was found that the odds of purchasing soda were almost 73% lower for customers who purchased water from the HWI water store versus noncustomers who used municipal tap as the main drinking source (OR=0.275, 95% CI=0.096, 0.787, $p<0.05$). Occupation was not evaluated as a predictor because 93% of the post-intervention surveys came from farmers. Additionally, this connection was not evaluated for the Socoyou community since the number of liters of soda purchased was essentially the same for both customers and noncustomers. For the Sesajab community, however, the data did support the finding that the number of liters of soda purchased was less among HWI water store customers. When customers from the Sesajab community were asked how the project has impacted their life, nine out of the ten households who responded spoke about the convenience of the water store in their community. Customers from the Socoyou community also spoke of convenience, but the theme of health was more prominent in their responses than convenience. This theme supports the connection found in that the convenience of the water store in the Sesajab community has led to more households buying less soda and drinking more water instead. Since the water being consumed from the HWI water store is cleaner and safer than a municipal tap or surface water source, the rates of diarrheal disease will hopefully decrease in the community as a result. It is also an important finding that should be

emphasized in future water stores as well, stressing the importance of the convenience of clean water being available to people in the community.

Limitations

There were several limitations for this evaluation. First, there was a lack of variability in the explanatory variables. The baseline surveys from Sesajab showed a community that was almost entirely domestic employees who used wells as the main drinking source while Socoyou was a community of all farmers who used surface water as their main drinking source. However, the post-intervention data showed primarily farming as the occupation and this did not differ between customers and noncustomers. This lack of variability within each time point, and lack of consistency in the population make-up between time-points, greatly decreased the statistical analyses that were possible for the data. However, overall trends were still able to be assessed. One improvement would be to ensure surveys are obtained from an equal representation of the different occupations and drinking sources in order to ensure a representative sample is collected. Another option could be to adopt a more systematic sampling method which could include randomly sampling households through a block random sampling method. This could help ensure that there are equal proportions of different types of households surveyed instead of having baseline surveys that come primarily from one type of household. This will lead to greater statistical

analysis that will confirm the role of the intervention in the differences seen in the data.

Second, there was also a lack of variation in the outcome data. In the post-intervention surveys, the number of diarrheal episodes and number of school days missed was the same for both customers and noncustomers. Again, this limited the number of statistical analyses that could be done because of the lack of variability. Sampling a larger number of individuals in the community would most likely increase the variability in the sample and work to make representative samples that show customers of the water store had different outcomes than noncustomers who did not use the water store.

Lastly, there are improvements to be made in the overall study design that would lead to greater precision and strength in the data collected from HWI. Survey questions differed from the baseline and post-intervention surveys as well as between the customer and noncustomer surveys. While it is possible to add in questions for the customers that help HWI learn about things such as how they heard about the store and why they switched water sources, creating surveys that are more similar between the three different groups would expand the number of explanatory variables and outcomes that could be assessed for impact. This could be improved by asking similar questions every time and trying to survey the same people before and after the intervention. Because of this, there were less explanatory variables available which made direct baseline and post-intervention comparisons difficult.

Future Direction and Recommendations

When looking at future monitoring and evaluation plans, the results of this evaluation suggest that HWI should take time to refine their survey questions in order to improve the design and capture a representative sample of the communities in which they are working. This could involve creating surveys that have more similar questions between the baseline and post-intervention groups in order to create more explanatory variables and outcome measures that could be used to measure impact. This could also involve taking time to collect more surveys in each community. A greater number of surveys from each community ensure a representative sample is collected, but it also ensures HWI can capture what is happening in each community.

A representative and comparable sample of surveys would also allow greater impact to be shown instead of just being able to report activities that are completed by the water store. Non-profits historically have only reported activities they are completing in a community. While bringing clean water is always a positive thing in a community, better data collection and analysis plans can ensure that the real impact of clean water in a community is quantified and shown. Not only does this help the non-profit by having sound data to share with donors, but it also gives them a greater picture and understanding of how this clean water store affects communities and what can be done in the future to ensure every water store is effective, efficient, and ultimately, helps make the community healthier. Additionally, impact data and association could be shown

to governments and other organizations from the country in order to leverage a systems approach to improving WASH infrastructure within countries. Adding partnerships with the government and other organizations will strengthen the effort to improve communities and will help reduce the WASH disparities seen in many countries today.

Conclusion

In conclusion, there were clear trends in the baseline data that differed from the post-intervention data. The number of diarrheal episodes, school days missed, and liters of soda purchased by households all decreased between the baseline and post-intervention survey results. However, the differences between customers and noncustomers for these variables did not differ as drastically. This suggests that there were changes between the baseline and post-intervention surveys, however, due to data quality and comparability issues we cannot attribute conclusively these differences to the HWI water store. The baseline households showed diarrhea as a strong predictor of missing school and purchasing soda as a predictor of diarrhea for the Sesajab community. The post-intervention households showed that customers using the HWI water store were less likely to purchase soda than households using a municipal tap water source. This suggests that the intervention may have had an impact on the customer households recognizing and carrying out healthier options which can lead to an overall healthier community.

While there were several limitations in the data, these findings are still relevant for HWI as they show the specific impacts their water stores are having on communities. Future studies should refine the survey questions and design in order to create a representative sample and help assess impact on a greater scale, and employ an independent group to carry out the surveys. Overall, this intervention does show that it is possible to bring water sources to rural settings, specifically in the poor region of Alta Verapaz, Guatemala. It also showed there are potential associations between bringing a new water source into the community and soda purchase which could help shape interventions to create healthier communities. It is important that governments and organizations continue to ensure programs are undergoing extensive monitoring and evaluation, including data collection, analyzing, and reporting, to ensure all interventions are having the desired outcomes and ultimately leading to healthier communities around the world.

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