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Evaluating the Long-Term Health Impact of Household Chlorination of Drinking Water in Rural Haiti

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Evaluating the Long-Term Health Impact of Household Chlorination of Drinking Water in Rural Haiti

By

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B.S. Chemical Engineering
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2009

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An abstract of
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Abstract

Evaluating the Long-Term Health Impact of Household Chlorination of Drinking Water in Rural Haiti

By Eric Harshfield

Background: In rural Haiti, 50% of households use unimproved drinking water sources and 25% of children under five have diarrhea. Since 2002 the Jolivert Safe Water for Families (JSWF) program has addressed these issues by training Haitian technicians to: 1) manufacture quality-controlled sodium hypochlorite solution (chlorine); 2) enroll participants through sale of safe storage containers; 3) sell chlorine to participants; 4) maintain household sales records; 5) conduct household visits to monitor chlorine use and provide ongoing education.

Objectives: There has been significant recent criticism in the literature of the lack of sustained health impact in household chlorination programs. This study examined the effect of JSWF program enrollment on diarrheal disease, compared with non-enrolled controls.

Methods: Study participants were randomly selected from a list containing 2,670 program households enrolled from September 2002 to May 2010. Two control households were selected for each participant by walking three houses to their right. At each household enumerators: 1) administered a 15-minute survey covering demographics, water collection/storage/treatment, and health outcomes; 2) measured remaining volume of chlorine since purchase; 3) tested free chlorine residual using Hach Color Wheel Chlorine Test Kit; 4) recorded GPS coordinates. Differences between participants and controls were examined using Pearson's chi-square tests and two-sample t-tests. Multivariate logistic regression models were developed, accounting for household clustering and adjusting for potential confounders.

Results: The 201 participant and 425 control households had similar demographics. Forty-six percent of participants (vs. 5% of controls) reported treating their drinking water with program-supplied chlorine 24 hours prior to the survey; however, 56% (vs. 10%) had free chlorine residuals between 0.2-2.0 mg/L due to occasional use of other chlorine products. Participants had significantly less diarrhea (14% vs. 21%, $p<0.001$) with 26% reduced odds (OR=0.74, 95% CI 0.52-1.05). Among children under five, participant also had significantly less diarrhea (31% vs. 52%, $p=0.001$) with 55% reduced odds (OR=0.45, 95% CI 0.23-0.86).

Discussion: Diarrheal disease reduction after nearly eight years of program activity was comparable with many randomized, controlled interventions conducted over periods of one year or less. The JSWF program has achieved long-term behavior change among program participants, resulting in improved health.

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Abbreviations

CDC	Centers for Disease Control and Prevention
CI	Confidence Interval
DPD	*N*,*N′*-diethyl-*p*-phenylenediamine
DHS	Demographic and Health Surveys
DSI	Deep Springs International
GIS	Geographic Information System
GOW	Gift of Water
GPS	Global Positioning System
GIS	Geographic Information System
HWTS	Household Water Treatment and Safe Storage
IRB	Institutional Review Board
JMP	Joint Monitoring Programme for Water Supply and Sanitation
JSWF	Jolivert Safe Water for Families
MINUSTAH	United Nations Stabilization Mission in Haiti
MOL	Missions of Love
NGO	Non-governmental Organization
NTU	Nephelometric Turbidity Unit
OR	Odds Ratio
ORS	Oral Rehydration Solution
PCA	Principal Components Analysis
PoUWT	Point-of-Use Water Treatment
PSI	Population Services International

SDWA	Safe Drinking Water Alliance
SODIS	Solar Disinfection
SWS	Safe Water System
UNICEF	United Nations Children’s Fund
USAID	United States Agency for International Development
USD	United States Dollar
VIP	Ventilated Improved Pit latrine
WHO	World Health Organization

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Chapter 1: Introduction

1.1 Introduction and rationale

Limited access to safe drinking water and improved sanitation facilities is a significant challenge in Haiti. Only 11% of households have access to a private sanitation facility that safely separates fecal waste from the environment, while half the population (50%) defecates in the open (MSPP, 2007). Poor sanitation leads to contamination of drinking water sources. In rural Haiti, 50% of households use an unimproved drinking water source (MSPP, 2007). Although 21% of households self-report adding bleach or chlorine to their water as a means of disinfection, 76% report that they do not treat their water, and other methods such as boiling and adding citrus are reported by less than 3% of rural households (MSPP, 2007). Diarrhea was reported by 25% of children under five in rural households (MSPP, 2007), and it is the second leading cause of death in this age group in Haiti (WHO, 2008).

The Safe Water System (SWS) was developed by the Centers for Disease Control and Prevention (CDC) as a method to safely treat drinking water in the home. The SWS consists of three interventions: 1) water treatment with liquid chlorine (sodium hypochlorite); 2) safe storage of household drinking water; and 3) education and behavior change messages to encourage safe household water, sanitation, and hygiene practices (CDC, 2006). The safe storage container typically consists of a bucket fitted with a lid and tap, to which chlorine is added (Figure 1). This small amount of chlorine added to water inactivates most diarrheal disease-causing pathogens and provides residual protection from recontamination (CDC, 2008c). Numerous meta-analyses have summarized the impact of household chlorine treatment on diarrheal disease (e.g. Arnold

& Colford, 2007; Clasen et al., 2007; Fewtrell et al., 2005). In individual randomized, controlled trials, the SWS has been shown to reduce diarrhea by 22-84% (CDC, 2006).

In September 2002, a SWS program was established at the Missions of Love (MOL) health clinic in the rural, northwestern community of Jolivert, Haiti. The non-governmental organization (NGO) Deep Springs International (DSI) currently operates the program, training Haitian technicians to: 1) manufacture quality-controlled liquid sodium hypochlorite (chlorine), which is branded "Gadyen Dlo" ("Water Guardian"); 2) enroll participating families through the sale of safe storage containers consisting of modified buckets with lids and taps; 3) sell Gadyen Dlo to participating families; 4) maintain sales records for each participating family; and 5) conduct regular household visits to monitor Gadyen Dlo use and provide ongoing education. The Jolivert Safe Water for Families (JSWF) program has reached over 4,700 participants since program inception and has sold roughly 48,000 chlorine refills, enough to treat 12,000,000 liters of water total or about 10.7 bottles per family on average (Turbes, 2011).

Figure 1: Safe storage container and bottle of chlorine used in Jolivert Safe Water for Families program

Photo source: Michael Ritter, Deep Springs International
(https://www.scientificamerican.com/slideshow.cfm?id=haiti-cholera-clean-water-chlorine)

1.2 Problem statement

Household chlorine treatment has been well-documented to reduce diarrheal disease in numerous short-term intervention studies; however, critics claim that chlorine uptake diminishes and health impact becomes negligible in the long-term (Hunter, 2009; Sobsey et al., 2008). Another criticism is that household chlorination programs are ineffective unless promoted alongside sanitation improvements (Eisenberg et al., 2007). This study is an impact evaluation that assesses consistency of use and diarrheal disease reduction in a long-term household chlorination program. The findings from this study will provide valuable documentation for implementers of household chlorination programs throughout the world regarding the scaling up or discontinuation of these programs, and will help inform the expansion of DSI's program.

1.3 Purpose statement

This study provides an important contribution to program implementers due to the current lack of research on the long-term effectiveness and health impact of household chlorination programs. This study addresses the following questions: 1) Do households enrolled in the JSWF program have significantly higher chlorine use than non-enrolled control households? 2) Do households enrolled in the JSWF program have significantly reduced point prevalence of diarrhea than non-enrolled control households, while adjusting for household characteristics that may confound the relationship between program enrollment and diarrheal disease?

1.4 Significance statement

Despite the extensive research documenting the significant health impact of household chlorination, few studies have been conducted for longer than one year and most of these studies have been randomized, controlled intervention trials. In a programmatic setting, the effectiveness of household chlorination is less well understood. This research will evaluate whether consistency of chlorine use can be maintained in a long-running program and whether there is a statistically significant diarrheal disease reduction in the context of an existing program that is not specifically designed to demonstrate such a difference, as in most epidemiological efficacy studies.

The JSWF program has several unique aspects that warrant the evaluation of this program. First, the staff members running the program are all Haitian. Second, the components of the program are all produced locally. The chlorine is produced at the clinic where it is sold; the hardware, including the buckets, bucket lids, and bottles, are manufactured in Haiti. The one exception to this is the bottle caps and spigots, which are shipped from the United States because they are not available locally. However, DSI technicians outfit the buckets with a spigot, lid, and DSI label with instructions at the clinic itself. Third, the chlorine is sold at a slight profit margin so that program staff are fully paid using program income (CDC, 2006). Lastly, technicians provide regular household visits and ongoing health education to encourage families to continue using their buckets and treating their water after purchase.

1.5 Definition of terms

This thesis refers to a number of terms with precise meanings. An *improved drinking water source*, according to the WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation (JMP), is defined as a source that is protected from outside contamination, including piped water into a dwelling, public taps or standpipes, tubewells and boreholes, protected dug wells, protected springs, and rainwater collection (WHO/UNICEF, 2010). *Unimproved drinking water sources* include unprotected dug wells, unprotected springs, carts with a small tank or drum, tanker trucks, surface water (including rivers and streams), and bottled water (WHO/UNICEF, 2010).

An *improved sanitation facility* is defined as one that hygienically separates human excreta from human contact, including flush or pour-flush toilets to a piped sewer system, septic tank, or pit latrine; ventilated improved pit (VIP) latrines; pit latrines with a slab; and composting toilets (WHO/UNICEF, 2010). *Unimproved sanitation facilities* include flush or pour-flush toilets to elsewhere, pit latrines without a slab (open pit), buckets, hanging toilets or hanging latrines, shared facilities of any type, and no facilities or use of bushes or fields (WHO/UNICEF, 2010).

Diarrhea is defined by the World Health Organization (WHO) as three or more loose or watery stools in a twenty-four hour period.

A *positive chlorine residual* is defined as between 0.2-2.0 mg/L of free chlorine in a water sample.

Chapter 2: Comprehensive Review of the Literature

2.1 Introduction

Disparities between urban and poor areas in Haiti are pronounced (MSPP, 2007). In light of the January 12, 2010 earthquake and the cholera outbreak beginning in October 2010, the needs for improved drinking water sources and improved sanitation facilities in Haiti are more pressing than ever. Limited use of improved drinking water and sanitation facilities contributes to a high prevalence of diarrheal disease, which particularly impacts the morbidity and mortality of young children (Rudan et al., 2007). This chapter will first describe the characteristics of households in rural Haiti and the drinking water and sanitation situation. Then it will discuss point-of-use water treatment (PoUWT) interventions, also known as household water treatment and safe storage (HWTS), which have been shown to be effective in reducing diarrheal diseases. Household chlorination is a particular PoUWT intervention that will be focus of this study. The SWS, developed by the CDC, combines household chlorination with safe storage and behavior change communication. The JSWF program, currently operated by DSI in the Northwest and Artibonite departments of Haiti, has been providing the SWS to families for over eight years. The safe storage container and locally produced chlorine are sold at the MOL clinic in Jolivert and are also available from resellers throughout the program area. The majority of enrolled program households are located in rural villages, but many enrolled households live in urban areas as well. This chapter will conclude by discussing the arguments raised by critics questioning the long-term sustainability and effectiveness of household chlorination programs. This research therefore provides a unique opportunity to evaluate the long-term health impact of DSI's program.

2.2 Haiti household characteristics

In Haiti, which is the poorest country in the western hemisphere (CIA, 2009), 70% of the population lives on less than 1 USD per day (MSPP, 2007). There are highly evident disparities between urban and rural areas in Haiti: 88% of rural households do not have electricity, while only 31% of urban households do not have electricity (MSPP, 2007). Likewise, 56% of rural households have a dirt floor while only 10% of urban households have a dirt floor, with the majority (81%) of urban households instead having a cement or concrete floor (MSPP, 2007).

A large proportion of rural households own livestock: 80% of households own land for agriculture and 72% own farm animals (MSPP, 2007). This may contribute to contamination of drinking water sources. Only 5% of females and 6% of males in rural areas have completed primary education (MSPP, 2007), while only 1% of females and less than 2% of males in rural areas have completed secondary education (MSPP, 2007). Low education levels may indicate that many households do not know how to properly treat their drinking water.

While over 50% of households in rural areas have a radio, only 8% have a television (MSPP, 2007). In 2006, only 6% of households in rural areas had mobile phones (MSPP, 2007), but after extremely rapid increases in mobile phone coverage in the past few years, 50% of rural households have mobile phones (Ashley & Scheuren, 2010).

2.3 Use of improved drinking water and sanitation facilities in Haiti

Use of improved drinking water sources in rural areas has made slight improvements in Haiti over the last two decades, increasing from 41% in 1990, to 49% in

2000, to 55% in 2008. Use of improved drinking sources in urban areas was 71% in 2008, up from 62% in 1990.

The most common sources of drinking water in rural areas (reported by 45% of households) are surface water (including rivers and streams) and other non-protected sources such as natural springs (MSPP, 2007). Most households in rural areas live close to these sources, as 53% of households take less than 30 minutes to collect water (MSPP, 2007). Addition of bleach is the most common water treatment method to be practiced according to self-reports, with 21% of households in rural areas reporting adding bleach or chlorine (MSPP, 2007). Only 1% of households in rural areas boil their water and 76% do not treat their water at all (MSPP, 2007).

Use of improved sanitation facilities in rural areas has actually decreased in Haiti over the last two decades, from 19% in 1990, to 15% in 2000, to 10% in 2008 (WHO/UNICEF, 2010). In urban areas use of improved sanitation facilities has also decreased from 44% in 1990 to 24% in 2008 (WHO/UNICEF, 2010). Haiti is the only country in the world included in the JMP report to see a decrease in use of improved sanitation facilities over the past two decades (WHO/UNICEF, 2010). This could be partially due to pronounced inequalities, high levels of corruption, and extreme poverty.

Unimproved sanitation facilities can contaminate drinking water supplies, which especially poses health risks when untreated surface water is used as the primary source of drinking water. In rural areas, 11% of households have an improved, private sanitation facility and 39% have an unimproved sanitation facility (MSPP, 2007). Many families do not even have a toilet, as 50% defecate in the open (MSPP, 2007).

2.4 Waterborne and diarrheal diseases in Haiti

Diarrhea commonly occurs among children in Haiti. In rural areas, 25% of children under five had diarrhea in the two weeks preceding the 2005-2006 Demographic and Health Survey (DHS) and 6% had blood in the stools (MSPP, 2007). Diarrheal diseases can result in decreased food intake and nutrient absorption, malnutrition, reduced resistance to infection, and impaired physical growth and cognitive development (Baqui et al., 1993; Guerrant et al., 1992). Diarrheal disease is the primary health problem in children under five (PAHO, n.d.) in Haiti. It is also the second-leading cause of reported deaths in Haiti's overall population (WHO, 2008).

Although knowledge of diarrhea treatment is high in Haiti, actual provision of treatment remains low. In rural areas, 96% of mothers with children under five have heard of oral rehydration solution (ORS) for the treatment of diarrhea, but only 35% of children under five who had diarrhea in the two weeks preceding the DHS survey received ORS (MSPP, 2007).

2.5 Point-of-use water treatment in Haiti

PoUWT has been shown to prevent transmission of waterborne diseases (CDC, 2008b). According to the WHO, interventions to improve water, sanitation, and hygiene could reduce the global burden of diarrheal disease by 9% and prevent 6% of all deaths (Pruss-Ustun et al., 2008).

Use of PoUWT methods is associated with drinking water source and household wealth. When water is stored in the home it requires PoUWT even if the water is collected from a microbiologically safe source. In Haiti, 37% of households with an improved drinking water source reported using a PoUWT method, compared with only

23% of households with an unimproved source (Rosa & Clasen, 2010). In the poorest household wealth quintile, 19% of households reported using a PoUWT method, compared with 53% of households in the highest wealth quintile (Rosa & Clasen, 2010).

Household chlorination, solar disinfection, ceramic filtration, biosand filtration, and the Procter & Gamble flocculant/disinfectant powder PUR® have all been demonstrated as effective interventions to reduce diarrhea in developing countries (CDC, 2008b). Out of these options, the particular advantages of household chlorination are that it provides residual protection against contamination and is low cost, easy to use, acceptable to users, able to be locally produced, and scalable (CDC, 2008b). A wide variety of household chlorination products, including Gadyen Dlo, Aquatabs, and Dlo Lavi, are available in Haiti.

A drawback of household chlorination is its difficulty removing pathogens in turbid water (Kotlarz et al., 2009; Preston et al., 2010). A single dose of chlorine effectively treats water up to 10 Nephelometric Turbidity Units (NTU), and a double dose can treat turbid water less than 100 NTU (Lantagne, 2008). Most families in rural Haiti collect water from non-turbid sources or they dig holes beside surface sources such as rivers to naturally filter water through the soil (Brin, 2003). Drinking water sources rarely exceed 10 NTU (Lantagne, 2008).

An additional concern is that chlorine is ineffective in removing some protozoan oocysts, such as *Cryptosporidium* (Lantagne & Clasen, 2009). The extent to which this is a problem in Haiti is not fully known, but nevertheless complete removal of bacterial pathogens in disinfected water has been demonstrated in numerous studies (Crump et al., 2004; Crump et al., 2005; Quick et al., 2002; Quick et al., 1996; Quick et al., 1999).

2.6 The Safe Water System

While chlorine is produced in numerous forms through a variety of distribution channels, the majority of studies on household chlorination have used liquid sodium hypochlorite (chlorine) with the SWS implementation strategy (Lantagne & Clasen, 2009). The SWS was developed by the CDC as a method to safely treat drinking water in the home using chlorine. The SWS campaign consists of three steps: 1) treatment of drinking water with chlorine, 2) safe storage of drinking water in a bucket with a lid and tap, and 3) behavior change communication on water, sanitation, and hygiene (CDC, 2006). A small amount chlorine added to water can inactivate most pathogens and provide residual protection (CDC, 2006). Thirty minutes after adding a capful of quality-controlled chlorine, the water is safe to drink (CDC, 2006).

There has been some concern that disinfection by-products are produced by treatment of drinking water with chlorine (CDC, 2004). However, a study of six drinking water sources in western Kenya found that none produced trihalomethanes in quantities that pose a significant health risk to SWS users (Lantagne et al., 2008).

2.7 Impact of household chlorination on diarrheal disease

Numerous studies have been conducted to determine the impact of household chlorination on diarrheal disease. A meta-analysis found a 47% reduction in the rate of diarrhea for children under five for household using chlorine (rate ratio = 0.53, 95% CI = 0.23-1.23) and a 40% reduction in the risk of diarrhea for the same age group (risk ratio = 0.60, 95% CI = 0.41-0.87) (Clasen, et al., 2007). An independently conducted meta-analysis published in the same year found that household chlorination reduced the risk of diarrhea in children under five by 29% (risk ratio = 0.71, 95% CI = 0.58-0.87) (Arnold &

Colford, 2007). While the magnitude varies across different studies, it has been repeatedly determined that household chlorination is highly effective in reducing diarrheal disease.

It is important to note that while all of the studies included in these meta-analyses were randomized controlled intervention trials with excellent methodologies, they were still efficacy studies focused on household chlorination in controlled research environments. In these studies, families using the SWS were provided with the product for free and were continually encouraged to use the product by the researchers. The products were often replaced by the researchers on a weekly basis (Crump, et al., 2005; Luby et al., 2004; Lule et al., 2005; Quick, et al., 1999; Reller et al., 2003), and households were sometimes provided with reimbursed medical expenses (Chiller et al., 2006; Crump, et al., 2005; Lule, et al., 2005) and incentives such as ORS packets (Crump, et al., 2005). Naturally, when the SWS is used in a programmatic setting, operated by an NGO over a long time period, the infeasibility of such close monitoring could lead to different results. The program described in the following section offers a unique opportunity to measure the long-term effectiveness, rather than the efficacy, of household chlorination.

2.8 Jolivert Safe Water for Families program overview and history

In September 2002, a household water chlorination program using the SWS model was established at the MOL health clinic in the rural community of Jolivert in the Northwest and Artibonite Provinces of Haiti. The JSWF program was started as a pilot project with 200 families, operated by MOL, a faith-based NGO with headquarters in Hartford, Kentucky (CDC, 2005). DSI took over ownership of the program in 2007.

The liquid chlorine, which was originally branded “Dlo Pwop” (“Clean Water” in Haitian Creole), is produced by trained technicians at the clinic using a sodium hypochlorite generator (CDC, 2005) (Figure 2). When a probe is immersed in a 3% sodium chlorine solution (brine) and direct current is passed through the probe, a simple chemical reaction transforms the brine into sodium hypochlorite solution (CDC, 2008c). Technicians at the clinic can make a 17-liter batch in two hours with a medium-sized generator, which can provide 68 households (over 400 people) with sufficient chlorine for one month (CDC, 2008c). The pH is tested and adjusted if necessary to ensure adequate shelf life (CDC, 2008c).

At the clinic families purchase a safe storage container, consisting of a five-gallon bucket modified with a tap and lid (Figure 1), and return regularly to purchase refills of chlorine in 250 mL bottles for 0.10 USD. Each bottle provides approximately 1.5 months of safe water when used appropriately. Alternatively, families can purchase chlorine from resellers in villages and towns throughout the program area for 0.16 USD, with the margin going to the resellers. The income from the program fully covers the salary for program staff and administrative expenses (CDC, 2005).

Figure 2: Chlorine production by Jolivert Safe Water for Families program staff

Photo source: Author

An independent evaluation conducted in the early stages of the project, with a survey of 113 randomly selected households, found that correct use of the SWS resulted in a 55% reduction in diarrhea among users (Brin, 2003). The recommendations from this study encouraged the program to expand to over 1,000 families by 2005 (CDC, 2005).

A study of the determinants of adoption in 2007 found that although the cost of the bucket is prohibitive for some families, the cost of the chlorine was not a barrier. Families living in communities far from the Jolivert Clinic had lower appropriate and consistent use. Households that were visited by technicians more frequently, usually those living closer to the clinic, had more consistent use. Behavior change campaigns using social marketing such as radio spots and posters were effective (Ritter, 2007).

The program has steadily expanded, and as of May 2010, the JSWF program has reached over 4,700 participants in 187 communities from Port-au-Prince to Port-de-Paix.

Over 48,000 chlorine refills have been sold, enough to treat 12,000,000 liters of water total and about 10.7 bottles per family. Average yearly growth in the number of enrolled households over the past three years has been 8.7%, although program records indicate even more rapid growth in the months immediately following the January 2010 earthquake (Turbes, 2011).

The technicians provide health education to families and conduct unannounced home visits to verify that families are properly treating their water and obtaining adequate chlorine residuals. Although the technicians aim to conduct one household visit every six months, program expansion, especially to areas farther from the clinic, has made it too difficult to achieve this goal.

2.9 Summary of current problem and study relevance

Critics have questioned the long-term sustainability of household chlorination programs, claiming that chlorine usage drops over time, that health impact becomes negligible, and that programs become too expensive to maintain. A blind, cross-over study found that the reduction in diarrhea among participants who used chlorine to treat their drinking water was negligible, but the results should be interpreted with caution since only twenty families were enrolled (Kirchhoff et al., 1985). In more recent literature, the development of household-level stochastic models of disease transmission led to the conclusion that water improvement interventions alone may have minimal impact on reducing diarrheal disease when sanitation conditions are poor (Eisenberg, et al., 2007). This conclusion undermines the legitimacy of the JSWF program, which does not have a sanitation component in a country with 50% open defecation in rural areas (MSPP, 2007). The meta-analysis previously cited, which found a 29% reduction in diarrhea using household chlorination, also found an attenuated effect of the intervention with longer study periods, although this finding was not statistically significant and the reason could not be explained (Arnold & Colford, 2007). Furthermore, a recent article stated that household chlorination “can in principle improve the microbiological quality of water and reduce diarrheal disease, but the available evidence suggests that [it does] not achieve sustainable, long-term, continuous use by populations once intervention studies end” (Sobsey, et al., 2008). A Monte Carlo simulation that analyzed 28 separate studies of randomly controlled trials of household water treatment, accounting for potential reporting bias in unblinded intervention studies, found that “disinfection-only interventions… appear to have poor, if any, long-term public health benefit” (Hunter, 2009). Another study stated that until further high-quality studies determine the effect of household water treatment on diarrhea, widespread promotion of household water treatment to reduce diarrhea is premature (Schmidt & Cairncross, 2009).

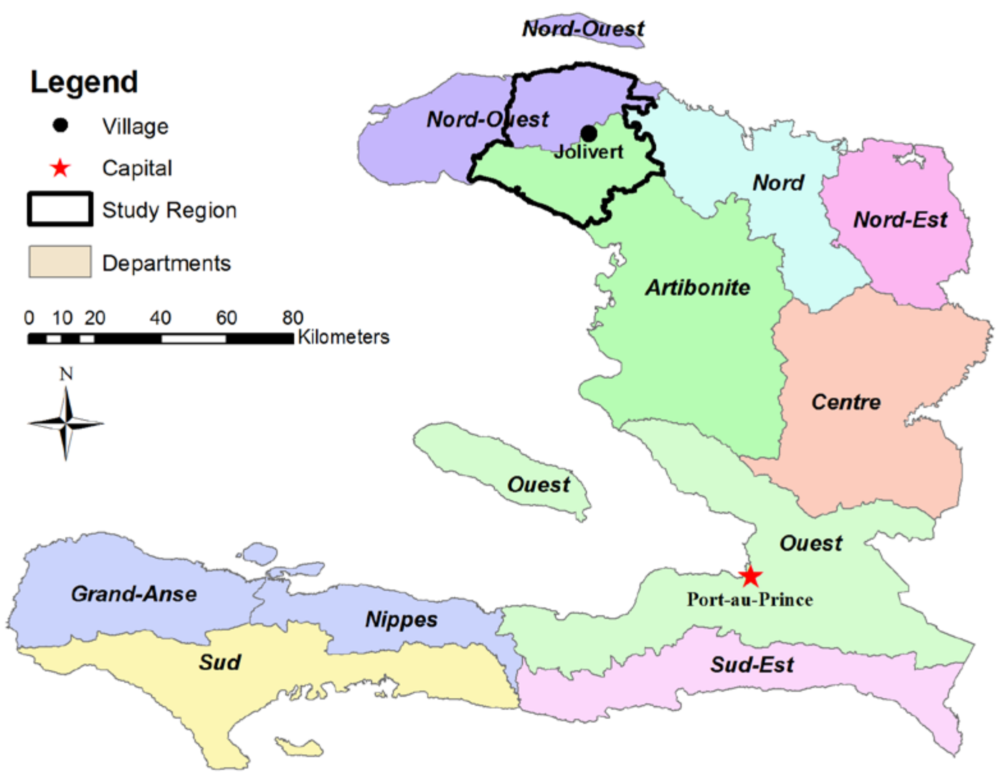
The JSWF program, which has been operating for over eight years distributing liquid chlorine at low cost to Haitian families with continuously maintained records, provides a unique opportunity to investigate these types of claims made by critics of household chlorination programs. The research presented here provides valuable information for implementers of household chlorination programs throughout the world regarding the long-term health impact of household chlorination and helps inform decisions to scale up or discontinue these programs.

Chapter 3: Methodology

3.1 Introduction

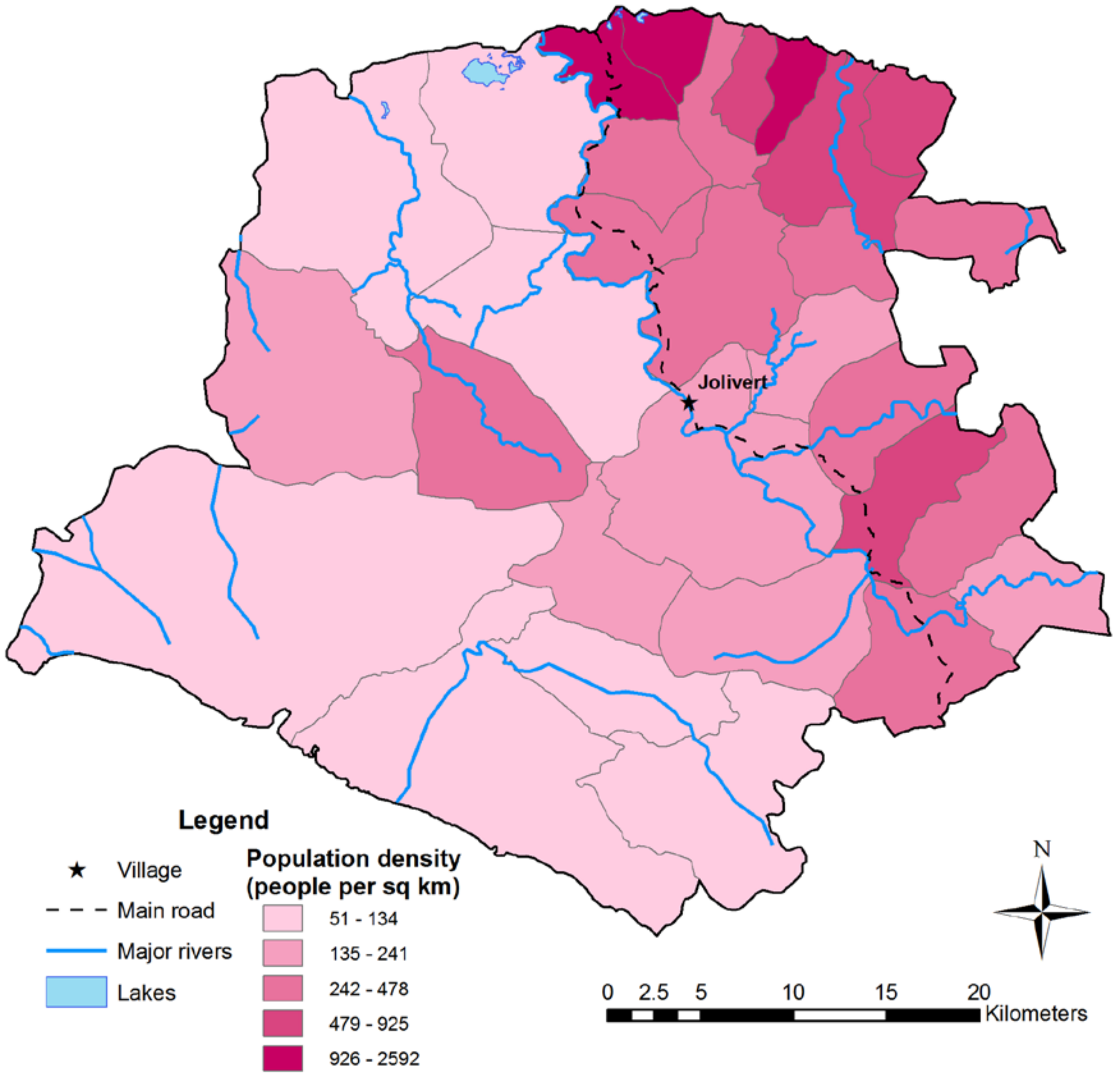
A survey to evaluate the differences in long-term diarrheal disease reduction in children under five between households enrolled in the chlorination program and control households was conducted in the JSWF program area. While the study region (Figure 3) excluded households located more than three hours of the MOL clinic by motorcycle, families enrolled in the program live throughout Haiti from Port-au-Prince to the north. The study region was defined by the borders of seven communes (Port-de-Paix, Bassin-Bleu, Chansolme, Saint Louis-du-Nord, Anse Rouge, Terre Neuve, and Gros Morne) located within the Nord-Ouest (North-West) and Artibonite Departments.

Figure 3: Map of study region within the Jolivert Safe Water for Families program area, which falls in both the Northwest and Artibonite Departments



The population density of communes within the study region varied from 51 to 2,592 people per square kilometer, with the most densely populated region in the northernmost Port-de-Paix commune (Figure 4).

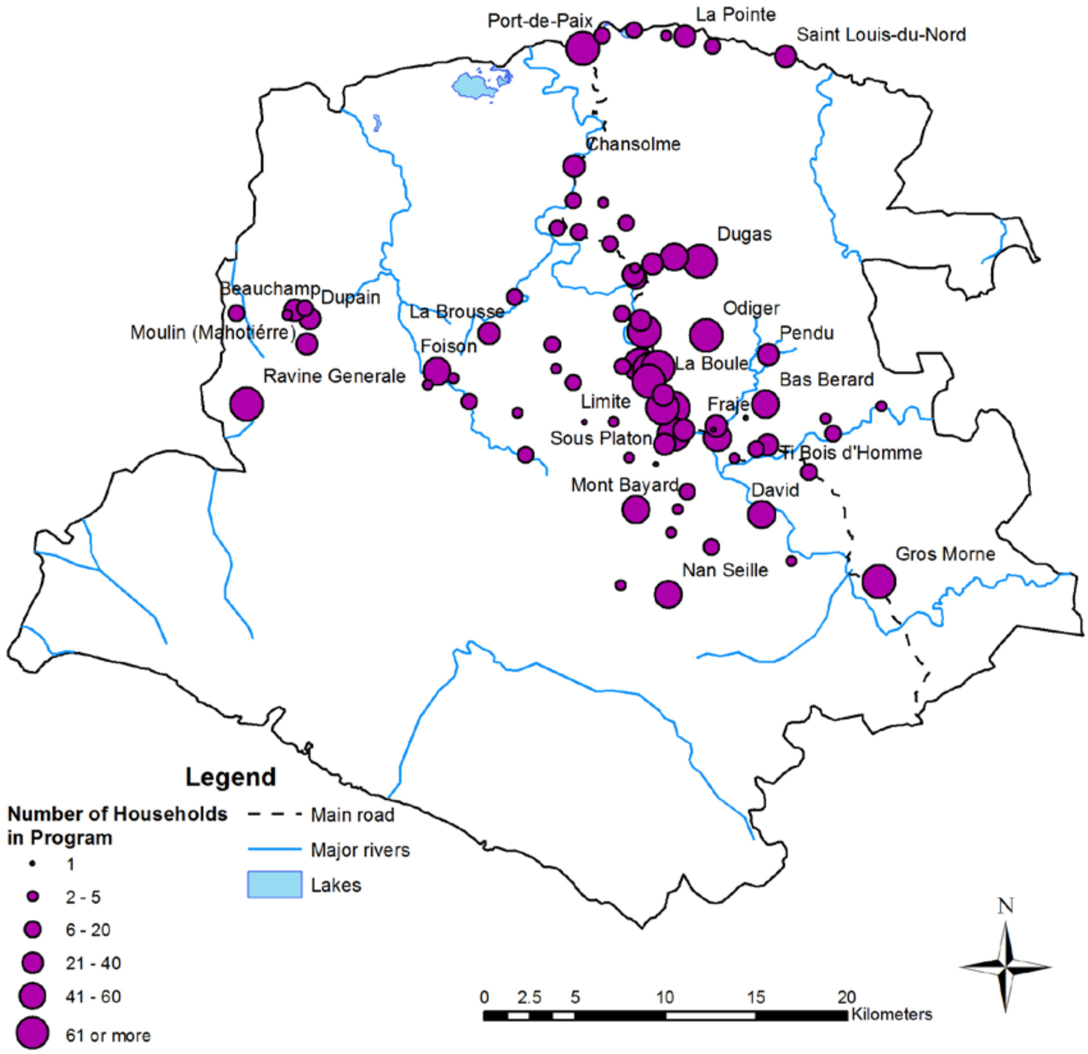
Figure 4: Population density map of communes in study region



3.2 Population and sample

The target population was households living in the JSWF program area. The technicians at the MOL clinic maintain paper records of bucket purchases, liquid chlorine purchases, and the results of free chlorine residual tests during routine household visits (Turbes, 2011). To develop the sampling frame, a list of households enrolled in the program was compiled by entering the paper records into Microsoft Office Excel 2007 (Redmond, WA, USA). Duplicate entries were identified in the Excel database using pivot tables and removed. Since program inception in September 2002 until May 2010, 4,253 households were enrolled from 182 communities. The majority of households live near the MOL clinic in Jolivert or along the main road (Figure 5).

Figure 5: Map of number of households enrolled in Jolivert Safe Water for Families Program per community



Records were excluded from the sampling frame if they met any of the following criteria: 1) the record referred to a group, such as a school, church, police station, or clinic; 2) the household was more than three hours away by motorcycle from the MOL clinic or would be too difficult for enumerators to get there and back in one day (including Port-au-Prince, Gonaïves, Jean Rabel, La Tortue, and Cap Haïtien); 3) the household was missing necessary information for an enumerator to locate them (i.e. family name or community name); 4) the household joined in the last three months; or 5) the household was used in the pilot survey, which was conducted over several days before beginning data collection. As a result, 2,670 households were initially included in the sampling frame (63% of program households met inclusion requirements). Consultations with DSI staff then led to the development of additional exclusion requirements. Thirty-one households were also excluded after randomization because the program coordinator could not provide clear directions to the enumerators on how to get to a particular village, or the household was in a larger city such as Port-de-Paix where the available information (name without a precise street address or at least a general area within the city) was insufficient to locate the person. In the event that a household was excluded, it was replaced with the subsequent household on the randomly sorted list.

Households were considered enrolled in the program ("participants") if they had a bucket purchase record in the handwritten notebooks kept at the MOL clinic, although this alone was not an indication that they used the bucket or purchased chlorine regularly. A random number between zero and one was generated in Excel for each household in the sampling frame and the list was sorted by this number. Enumerators visited each household on the list in order until reaching the target sample size of 200 participant households.

3.3 Research design

In order to ensure a suitable comparison group, two control households were selected for each participant household so that it would have been possible to drop controls that were not closely matched with participants on demographic characteristics while maintaining sufficient statistical power (Kang et al., 2009), although this ultimately was not done for the analysis as the two groups were sufficiently well-balanced from the outset (see Chapter 4: Results). The first control was selected by walking three houses to the right of the participant, and the second control was selected by walking three additional houses in the same direction. If a selected control household was not home, the enumerator selected the next closest household that appeared to be of a similar socio-economic status (i.e. similar construction material used for walls and roofs).

3.4 Procedures

Enumerators were trained over the course of two days to learn background information about the study and to understand the purpose of each survey question. During the training they learned how to ask the questions appropriately, practiced measuring the amount of Gadyen Dlo stored in the household and the free chlorine residual of drinking water, practiced recording GPS coordinates, and piloted the survey in households near the clinic. A research coordinator/translator was hired to assist the primary researchers, to translate instructions for the other enumerators, and also to conduct surveys.

The purpose of the study was explained by the enumerators in Haitian Creole to the survey respondent in each household before conducting the survey. The enumerators emphasized that participation was voluntary and that participants could withdraw at any time. The enumerators signed the survey to indicate that verbal consent was obtained. Institutional Review Board (IRB) approval from Emory University was requested and exemption was granted (see Appendix B: IRB Study Exemption Letter).

3.5 Instruments

The survey instrument contained 40 questions and took 10-15 minutes to complete. The topics included household demographics, assets, water sources, water treatment methods, knowledge and use of Gadyen Dlo, diarrhea among family members, treatment of diarrhea, and latrine usage. The survey was translated into Creole by a member of the DSI program staff working in Léogâne (see English version of survey in Appendix C: Household Survey). The survey was back-translated to English by a Haitian not associated with the program to verify the accuracy of the translation; no modifications were deemed necessary. After printing the survey and arriving at the field site, several changes were suggested by the research coordinator/translator and a DSI staff member, which were hand-corrected on the surveys; the answer choices were modified for one question and a new question was added.

The survey respondent was asked to report diarrhea, defined as three or more loose or watery stools in a 24-hour period, for all household members during the last 48 hours. The survey respondent was also asked to report whether or not blood was present in the stools (which helps provide an indication of dysentery) for all household members who had diarrhea.

Data were entered in Excel at the conclusion of each day of survey collection. Since ages of household individuals were entered in the database in years, ages of young children that were recorded on the survey in months were rounded to the nearest whole year in the database. Written-in responses were translated to English by the researchers with the assistance of the research coordinator/translator. Quality of data entry was verified by cross-checking implausible responses in the database with the original written surveys. If the intended response could be determined from the context, the mistake was corrected in the database.

The amount of purchased Gadyen Dlo remaining in the bottle was measured for each household using a graduated cylinder. Free chlorine residuals for drinking water in each home were measured with a Hach® Color Wheel Chlorine Test Kit (Hach Company, Loveland, CO), regardless of whether or not the household member reported that their drinking water was treated. A small quantity of drinking water was poured into two plastic viewing tubes and placed in the test kit. A package of powder *N*,*N′*-diethyl-*p*-phenylenediamine (DPD) reagent was emptied into one tube, and the other tube was used as a blank for comparison. A color wheel was used to estimate the chlorine residual accurate to within 0.1 mg/L and a range of 0-3.5 mg/L (CDC, 2008a). GPS coordinates were recorded at the entrance of each home with a Garmin® eTrex Vista 360° (Garmin International, Inc., Olathe, KS).

3.6 Analysis of survey data

The survey data were cleaned and analyzed in Stata 11.1 (StataCorp LP, College Station, TX). New variables that were created included reported use of an improved water source according to the JMP definition (WHO/UNICEF, 2010), reported presence of a latrine used by children in the household, reported use of a safe storage container for drinking water, free chlorine residual measurement between 0.2-2.0 mg/L, reported use of commercially available bleach to treat drinking water, and reported treatment of drinking water with Gadyen Dlo in the past 24 hours. An intention-to-treat analysis was used; that is, all households with records indicating enrollment in the JSWF program (participants) were included in the analysis regardless of whether they reported using Gadyen Dlo at the time of the survey or whether they actually had a positive free chlorine residual in their drinking water, and all controls were included in the analysis even if they reported using Gadyen Dlo or had positive chlorine residuals. Descriptive univariate statistics were calculated for all categorical and continuous variables, and contingency tables were calculated for all variables stratified by program participant or non-participant (control). Categorical variables with multiple levels were dichotomized into new variables, and differences in proportions between participants and controls were evaluated with Pearson's chi-square tests. Differences in the means of continuous variables were evaluated with two-sample t-tests. The alpha significance level of 0.05 was used for all statistical tests.

A wealth index was derived using a principal component analysis (PCA) for variables related to socio-economic status (Filmer & Pritchett, 2001). Rather than using household income as a measure of wealth, asking about items that the household owns has been shown to be a more reliable indicator of socioeconomic status in rural settings (Rutstein et al., 2004). Variables that were used to construct the wealth index included the type of walls, floors, and roofs used to construct the house; the reported number of beds, bicycles, poultry, sheep, cows, radios, and mobile phones owned; the reported drinking water source used; and reported ownership of soap and a latrine. The respondent was not asked about the type of latrine and if it was private or shared, so it was not possible to determine if the latrine was an improved sanitation facility according to the JMP definition (WHO/UNICEF, 2010). Categorical variables with multiple levels were converted into multiple binary variables for application of PCA. The first principal component (Table 13 in Appendix A: Principal Component Analysis), which accounted for 16.7% of the variation in the original data, was used to construct the wealth index using a correlation matrix so that all the data had equal weight (Houweling et al., 2003; Vyas & Kumaranayake, 2006). The wealth index was normalized to have an overall mean of zero and a standard deviation of one. Then the median and range wealth index for participants and controls were determined and a t-test for the difference in means was calculated.

Since diarrhea-related questions were asked for each individual in every household, analysis of health outcomes treated each individual as an observation rather than each household. Thus, if a household was a participant, then all individuals in that household were considered participants with identical household characteristics but unique responses to age, gender, diarrhea, and the presence of blood in the stools. The diarrhea prevalence was calculated overall and among children under five. The prevalence of bloody stools was also calculated. These three outcomes were also stratified by gender. The estimates and p-values calculated for diarrhea prevalence were not adjusted for clustering at the household level. To verify the robustness of the estimates, the same statistics were also calculated using ordinary least squares regression to account for household clustering, but this approach did not noticeably affect the estimates.

Odds ratios with 95% confidence intervals were calculated to determine the effect of being a program participant on having diarrhea and on having diarrhea with blood in the stools. Multivariate logistic regression models were developed to adjust for potential confounders in these relationships while also accounting for clustering at the household level. The basic models simply assessed the relationship between program enrollment and diarrheal disease. The full models assessed this relationship when controlling for potential confounders. Covariates in the full models were program participation, respondent gender, wealth index, time to collect water, turbidity in the household drinking water supply, presence of soap in the household, reported use of an improved drinking water source, use of a safe storage container, and reported use of a latrine by children in the household. Since the full models were conducted on slightly smaller samples due to missing observations, the restricted models were the same as the basic models but analyzed the samples from the full models.

The variables for presence of soap in the household, reported use of an improved drinking water source, safe storage of drinking water in the home, and reported use of a latrine by children in the household were also tested to determine if they interact with program enrollment.

3.7 Analysis of spatial data

Spatial data were obtained from a variety of sources. *Mission des Nations Unies pour la Stabilisation en Haïti* (MINUSTAH, the United Nations Stabilization Mission in Haiti) provided a shapefile containing administrative boundary polygons for Haiti—departments, communes, and sections—and shapefiles with major rivers and lakes. Open Street Maps provided a shapefile containing roads. These data were combined with the survey data, which were spatially referenced using GPS coordinates recorded at each household. Spatial data were georectified to the Universal Transverse Mercator zone

18N projection, 1984 datum, and analyzed in the Geographic Information System (GIS) software package ArcGIS 9.3 (ESRI, Redlands, CA).

Chapter 4: Results

4.1 Introduction

Since program inception in September 2002 up to May 2010, 4,253 households have been enrolled. The total population in the administrative communes where the JSWF program operates is 385,106, which consists of 63,857 rural households (IHSI, 2003). Program coverage is therefore approximately 6.7%.

This chapter will present the results of the household survey, beginning with a comparison of the differences between participants and controls on several demographic characteristics. Reported water collection and storage will be presented next. The spectrum of findings on Gadyen Dlo use, from voluntarily identifying the product to having a confirmed chlorine residual, will then be presented in-depth. Brief results on the reported use of other water treatment methods will also be presented. The results chapter will conclude by presenting the diarrheal disease findings among participants and controls and the results of the multivariate models.

4.2 Household survey

The target sample size was 200 participant households with 400 control households. There were 66 uncompleted participant surveys because the household members had recently moved away or died, they could not be found by the enumerators after two attempts on different days, or they refused to complete the survey. A total of 201 participant and 507 control households were surveyed, with a participant response rate of 75% (Figure 6). After removing households for whom participants and controls were not matched, the analysis was conducted on 201 participant and 425 control households with 3,122 individuals. These households lived in 72 communities, with between 1-24 households surveyed per community (Figure 7).

Figure 6: Map of survey households for whom GPS coordinates were recorded

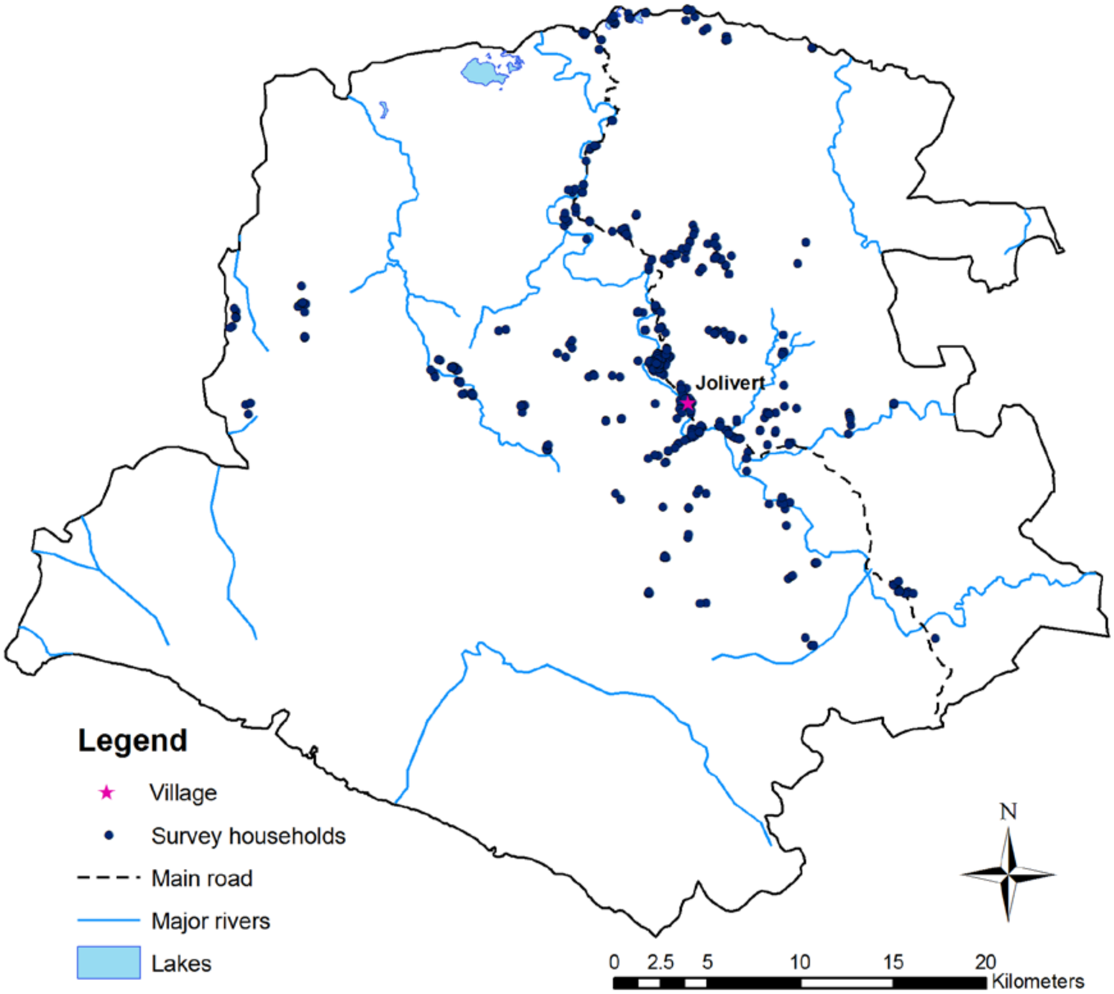
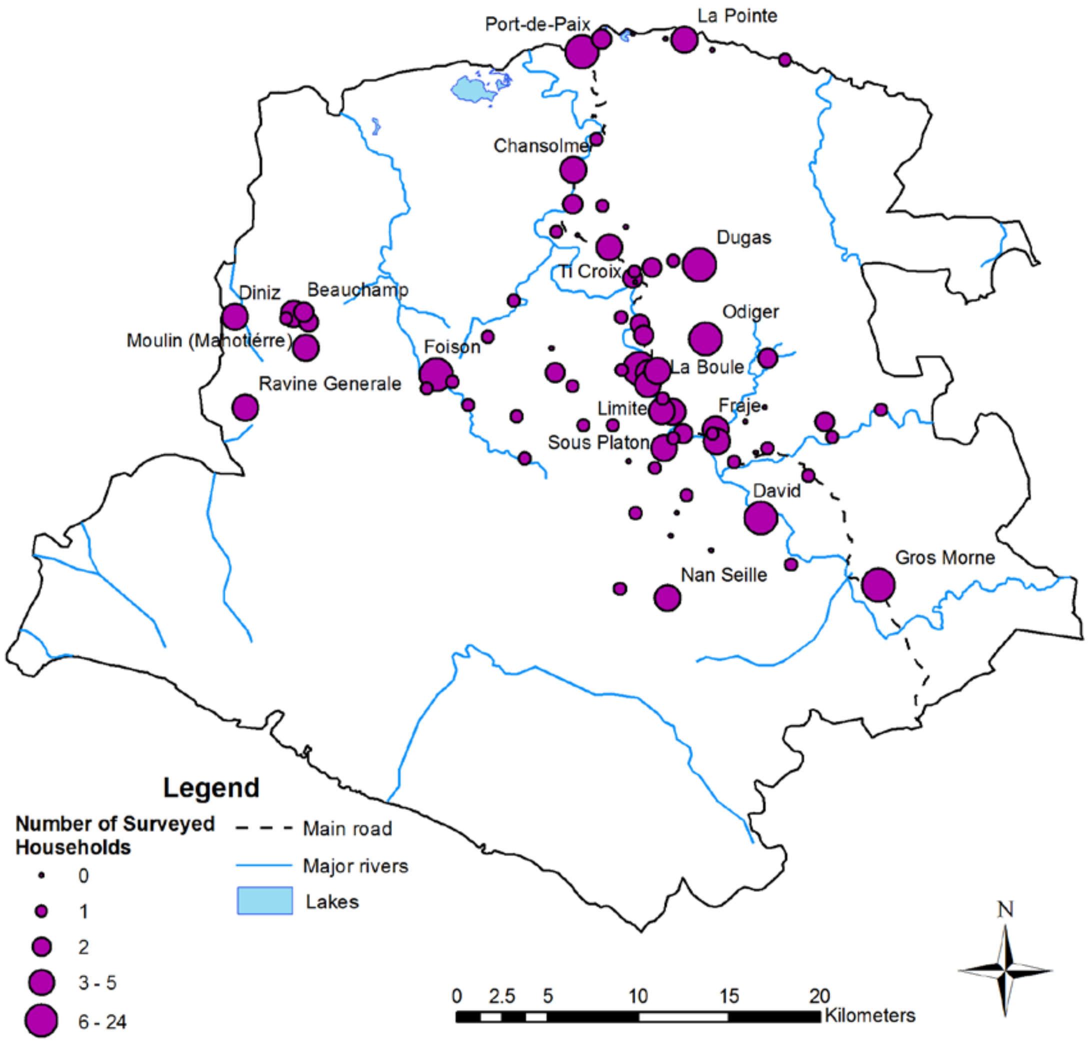


Figure 7: Number of surveyed households per community



4.2.1 Demographics

Demographics between participant and control households were very similar (Table 1). Participant households had an average of 5.7 members, while control households had an average of 5.6 members (p=0.585). The mean age of survey respondents was 40.5 for participants and 39.8 for controls (p=0.602). However, there were a few minor differences as significantly fewer participant than control respondents were female (64% vs. 74%, p=0.006) and practiced voodoo (5% vs. 15%, p<0.001). Significantly more participant respondents attended school (78% vs. 70%, p=0.032) and significantly more male household heads could read among participants than among controls (76% vs. 68%, *p*=0.034), but there were no differences in the literacy of female household heads.

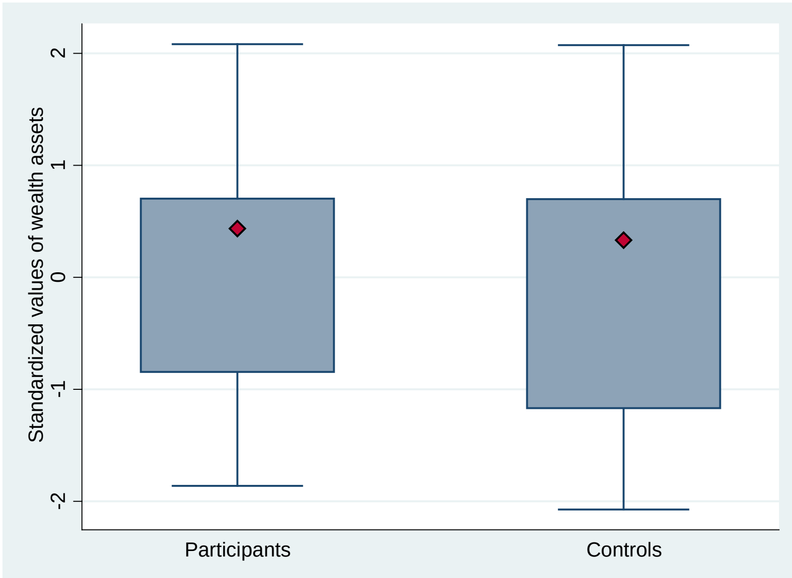
The wealth index had similar medians and ranges for participants and controls (Figure 8); although the t-test for the difference in means approached significance (*p*=0.086), there did not appear to be differences in socioeconomic status between the groups.

Out of the ten demographic characteristics considered, not including the 15 variables that were used to derive the wealth index (Table 13 in Appendix A: Principal Component Analysis), only three variables were significantly different between participants and controls. Overall, the two groups were quite similar.

Table 1: Household demographics among program participants and controls

Variable	**Participants**	**Controls**	***p***
No. (%) female respondents	128/201 (63.7)	316/425 (74.4)	0.006
Mean (SD) respondent age	40.5 (14.3)	39.8 (15.6)	0.602
No. (%) respondents who attended school	157/201 (78.1)	295/422 (69.9)	0.032
Mean (SD) years respondent attended school	9.3 (4.2)	8.8 (4.0)	0.196
No. (%) male household heads who can read	145/190 (76.3)	267/394 (67.8)	0.034
No. (%) female household heads who can read	133/199 (66.8)	259/421 (61.5)	0.200
Mean (SD) household size	5.7 (2.3)	5.6 (2.2)	0.585
Median (range) wealth index	0.4 (-1.8 - 2.1)	0.3 (-2.1 - 2.1)	0.086
Religion: no. (%)			
Catholic	73/201 (36.3)	177/415 (42.7)	0.133
Protestant	120/201 (59.7)	215/415 (51.8)	0.065
Adventist/Other	8/201 (4.0)	23/415 (5.5)	0.690
No. (%) respondents who practice voodoo	9/199 (4.5)	61/409 (14.9)	<0.001

Figure 8: Box plots of wealth assets for program participants and controls



4.2.2 Water collection and storage

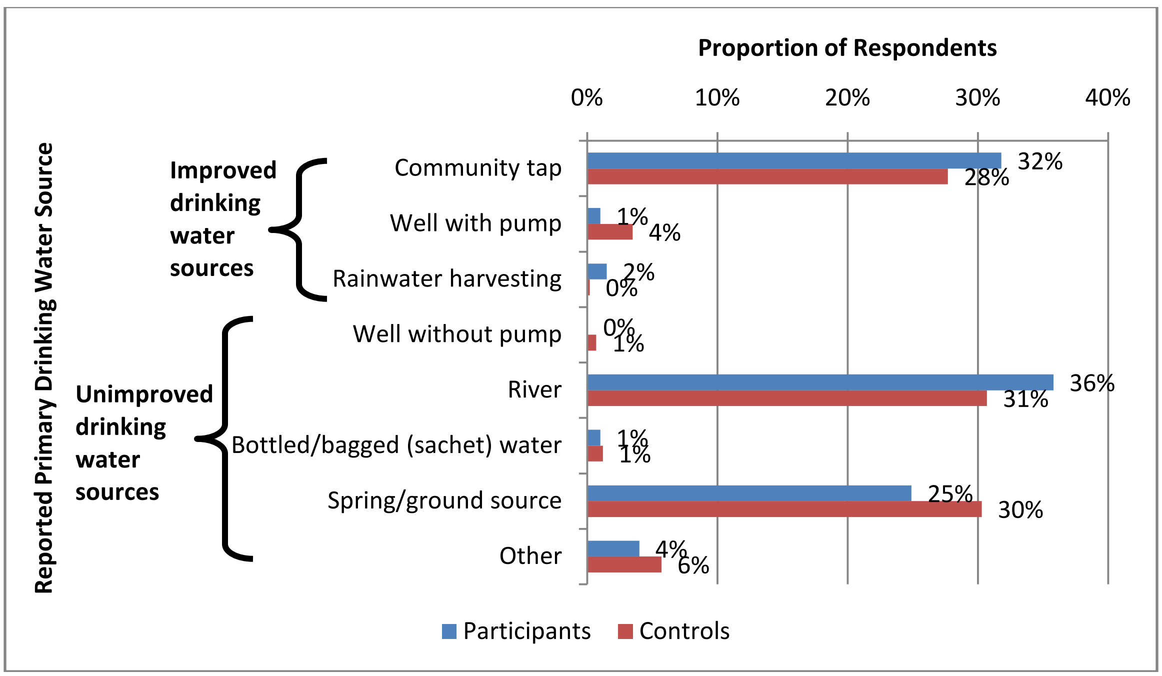
There were few significant differences in the reported primary drinking water sources (Figure 9). A community tap was used by 32% of participants and 28% of controls (p=0.237), and the river was used by 36% of participants and 31% of controls (p=0.052). An open spring or ground source was used by 24% of participants and 30% of controls (p=0.064). Use of an improved drinking water source did not significantly differ between participants and controls (Table 2). Participants collected water on average 2.2 times per day while controls collected water 2.5 times per day (p=0.010).

Not surprisingly, significantly more participants (94% vs. 61%, p<0.001) believed that their drinking water was safe to drink. The most commonly volunteered reason why they believed their water was safe to drink is that it was free from bacteria (91% vs. 66%, p<0.001). A larger but not significantly different percentage of controls incorrectly believed that their water was safe to drink because it was clear (31% vs. 25%, p=0.138).

Table 2: Water collection and storage among program participants and controls

Variable	Participants	Controls	*p*
No. (%) using improved drinking water source	69/201 (34.3)	133/423 (31.4)	0.471
Collect water times per day (mean, SD)	2.2 (1.0)	2.5 (1.4)	0.010
Time to collect water and return (mean, SD)	25.1 (26.1)	28.4 (31.4)	0.194
No. (%) who believe their water is safe to drink	161/172 (93.6)	184/303 (60.7)	<0.001
Why believe drinking water is safe: no. (%)	*n=199*	*n=424*	
Water is clear	48 (24.1)	130 (30.7)	0.092
Water is free of bacteria	181 (91.0)	281 (66.3)	<0.001
Water is from tap	13 (6.5)	28 (6.6)	0.973
Water is warm	0 (0.0)	2 (0.5)	0.332
Other	11 (5.5)	57 (13.4)	0.003
No. (%) using a safe storage container	53/201 (26.4)	28/425 (6.6)	<0.001
No. (%) using soap	109/190 (57.4)	209/386 (54.2)	0.465
No. (%) using a latrine	162/201 (80.6)	315/424 (74.3)	0.083

Figure 9: Reported primary drinking water sources used by participants and controls



4.2.3 Gadyen Dlo use

An important component of the JSWF program is unannounced technician household visits; the majority of participants heard about Gadyen Dlo from a technician (72%), compared with 10% of controls (p<0.001). Participants heard about Gadyen Dlo from a variety of other sources as well, including the radio (23%), relatives and friends (17%), and resellers (14%). The most commonly cited reasons for using Gadyen Dlo were that it prevents disease (95% vs. 17%, $p<0.001$) and cleans water (30% vs. 3%, $p<0.001$). A large number of participants said that they do not use Gadyen Dlo because they ran out (50%) or could not afford it (41%).

The vast majority of participants (71%) reported that they have received sufficient training on how to use Gadyen Dlo. However, only 37% of participants reported receiving a household visit from a technician although all participants in the program are supposed to receive regular visits. In addition to household visits, participants received training from other sources; 28% of participants received training at church and 11% received information about how to use Gadyen Dlo from a poster or pamphlet.

Survey respondents were asked about their water treatment methods, particularly Gadyen Dlo, numerous times throughout the survey in a variety of formats. First, survey respondents were asked to list all water treatment methods that they have heard of (Table 3); 97% of participants mentioned unsolicited that they had heard of Gadyen Dlo, compared with 40% of controls ($p<0.001$). Condition on voluntarily reporting having heard of Gadyen Dlo, 35% of participants reported using it every day, compared with 11% of controls ($p<0.001$), and a large proportion of participants (19%) reported only using Gadyen Dlo once. When explicitly asked whether they had heard of Gadyen Dlo, 96% of participants compared with 22% of controls ($p<0.001$) had heard of Gadyen Dlo, which was slightly fewer participants than had volunteered that same information.

Surprisingly, although 170 controls mentioned Gadyen Dlo unprompted when asked to list all known water treatment methods, less than half as many controls (84) stated that they had heard of Gadyen Dlo when explicitly asked. There may have been over-reporting when respondents were asked to voluntarily identify methods, because enumerators may have indicated Gadyen Dlo rather than circling “other” and writing in bleach (commercial bleach such as Clorox was not one of the responses for this question). There may have also been over-reporting when respondents were explicitly asked if they had heard of Gadyen Dlo because enumerators incorrectly asked the question. An affirmative response to this question required a whole series of questions about their use of Gadyen Dlo, and enumerators may have skipped these questions on some surveys in order to finish their work more quickly. After including the large number of missing responses to these skipped questions, 94% of participants reported having ever used Gadyen Dlo, 75% reported that they were using Gadyen Dlo now, and 46% reported having used Gadyen Dlo in the past 24 hours.

When survey respondents were asked if they had treated their current drinking water using any method, 79% of participants compared with 32% of controls ($p<0.001$) responded affirmatively. However, all survey respondents were requested to allow their drinking water to be tested and only 56% of participants and 10% of controls ($p<0.001$) had a positive chlorine residual in the acceptable range of 0.2-2.0 mg/L. The respondents were not asked if they had treated their current drinking water with Gadyen Dlo; other water treatment products, including commercial bleach, could have been used. This could explain why 46% of participants reported treating their drinking water with Gadyen Dlo in the past 24 hours but 79% reported treating their current drinking water using any method. Since only 56% of participants had positive chlorine residuals, some of the participants may have treated their drinking water with a product other than Gadyen Dlo but they might not have added the correct amount of commercial bleach, they might have stored their water for longer than the chlorine residual lasted, or they might have used a different water treatment method.

Out of those participants who had positive chlorine residuals, 89% had a bottle of Gadyen Dlo in their home. Out of all participants who did not have positive chlorine residuals, 38% had a bottle of Gadyen Dlo with chlorine remaining in the bottle. This proxy measure suggests that nearly a third of participants who are regularly using chlorine do not have positive chlorine residuals. These households must have added too little chlorine or the residual had dissipated and was undetectable at the time of the survey. As an indication of the degree to which controls were selected who should have been excluded, 33% of controls had a bottle of Gadyen Dlo in their home with chlorine remaining in the bottle. These controls were included in this intention-to-treat analysis, but they will be excluded in a further treatment-on-treated analysis.

Table 3: Gadyen Dlo reported & actual use among program participants and controls

Variable	Participants	Controls	*p*
No. (%) who reported having heard of Gadyen Dlo when asked to list all known water treatment methods	194/201 (96.5)	170/424 (40.1)	<0.001
No. (%) who reported using Gadyen Dlo, conditional on voluntarily reporting having heard of it			
Every day	65/191 (34.0)	18/168 (10.7)	<0.001
Once/week	71/191 (37.2)	13/168 (7.7)	<0.001
Sometimes	15/191 (7.9)	26/168 (15.5)	0.023
Once	36/191 (18.8)	8/168 (4.8)	<0.001
Never	4/191 (2.1)	103/168 (61.3)	<0.001
No. (%) who reported having heard of Gadyen Dlo when explicitly asked	192/200 (96.0)	84/390 (21.5)	<0.001
No. (%) who reported ever using Gadyen Dlo	181/194 (93.3)	57/389 (14.7)	<0.001
No. (%) who reported now using Gadyen Dlo	147/197 (74.6)	39/389 (10.0)	<0.001
No. (%) who reported treating their drinking water with Gadyen Dlo in the past 24 hours	90/197 (45.7)	21/390 (5.4)	<0.001
No. (%) who reported treating their current drinking water, using any method	153/195 (78.5)	129/404 (31.9)	<0.001
No. (%) who had a positive chlorine residual in their current drinking water between 0.2-2.0 mg/L	98/176 (55.7)	25/258 (9.7)	<0.001

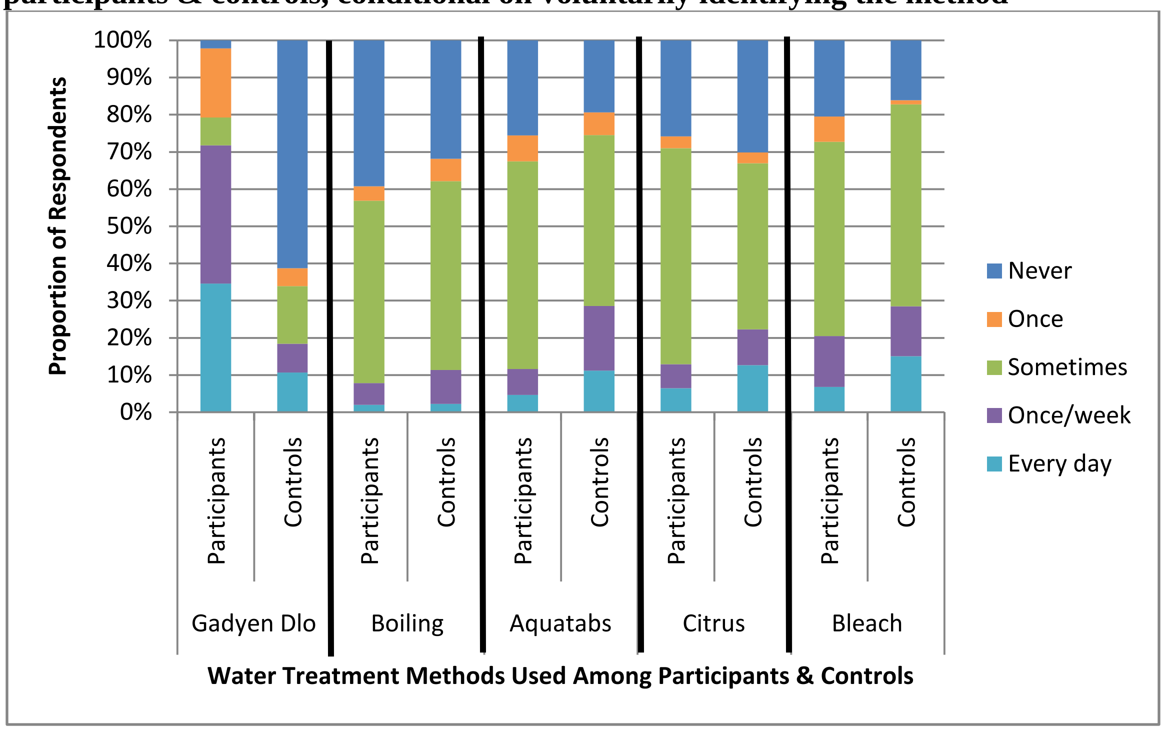
4.2.4 Other water treatment methods

Other water treatment methods were also used with regularity. Respondents were asked to list all methods that they had heard of (Table 4), and then they were asked how often they used each of these methods (Figure 10). Besides Gadyen Dlo, the methods that were most frequently reported used were boiling, Aquatabs, citrus, and commercial bleach products such as Clorox or Jif. Significantly more controls than participants (45% vs. 22%, $p<0.001$) reported having heard of a commercial bleach product other than Gadyen Dlo being used to treat water. Significant differences in the reported frequency of use of Gadyen Dlo between participants and controls are readily apparent in Figure 10; however, there were no significant differences in the reported frequency of use for the other water treatment methods among households who voluntarily identified having heard of the methods.

Table 4: Other water treatment methods among program participants and controls

Variable	Participants *n=201*	Controls *n=424*	*p*
No. (%) heard of boiling	54 (26.9)	138 (32.5)	0.150
No. (%) heard of Aquatabs	44 (21.9)	101 (23.8)	0.593
No. (%) heard of Dlo Lavi	7 (3.5)	17 (4.0)	0.749
No. (%) heard of raket	7 (3.5)	19 (4.5)	0.559
No. (%) heard of citrus	32 (15.9)	104 (24.5)	0.015
No. (%) heard of using a filter	3 (1.5)	6 (1.4)	0.939
No. (%) heard of PUR	3 (1.5)	2 (0.5)	0.181
No. (%) heard of commercial bleach (e.g. Clorox or Jif)	44 (21.9)	189 (44.6)	<0.001
No. (%) heard of other method	2 (1.0)	15 (3.5)	0.068

Figure 10: Frequency of using most common water treatment methods reported by participants & controls, conditional on voluntarily identifying the method



4.2.5 Health outcomes

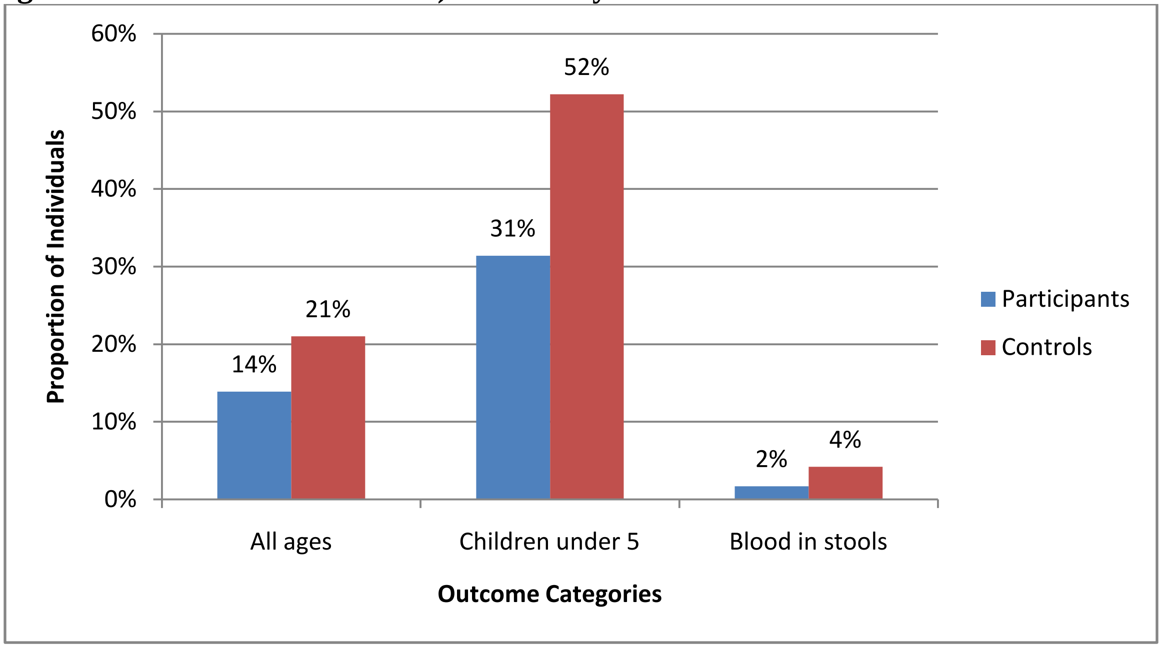
Since the survey respondent was asked to report health outcomes for each individual living in every household, for the following results each individual rather than each household was treated as an observation. The proportions of respondents with diarrheal disease amongst all ages and amongst children under five for males and females were significantly different between participants and controls (Table 5). The proportions who had diarrhea or bloody diarrhea are shown in Figure 11.

Only 14% of participants had diarrhea as compared with 21% of controls ($p<0.001$). These proportions were similar for both males and females. Amongst children under five, 31% of participants had diarrhea as compared with 52% of controls ($p=0.001$). More female participants under five (36%) had diarrhea than male participants under five (28%; $p=0.121$). This finding was also true for children under five living in control households. Participants with diarrhea also had significantly less blood in the stools (2% vs. 4%; $p<0.001$).

Table 5: Health outcomes among program participants and controls at household level

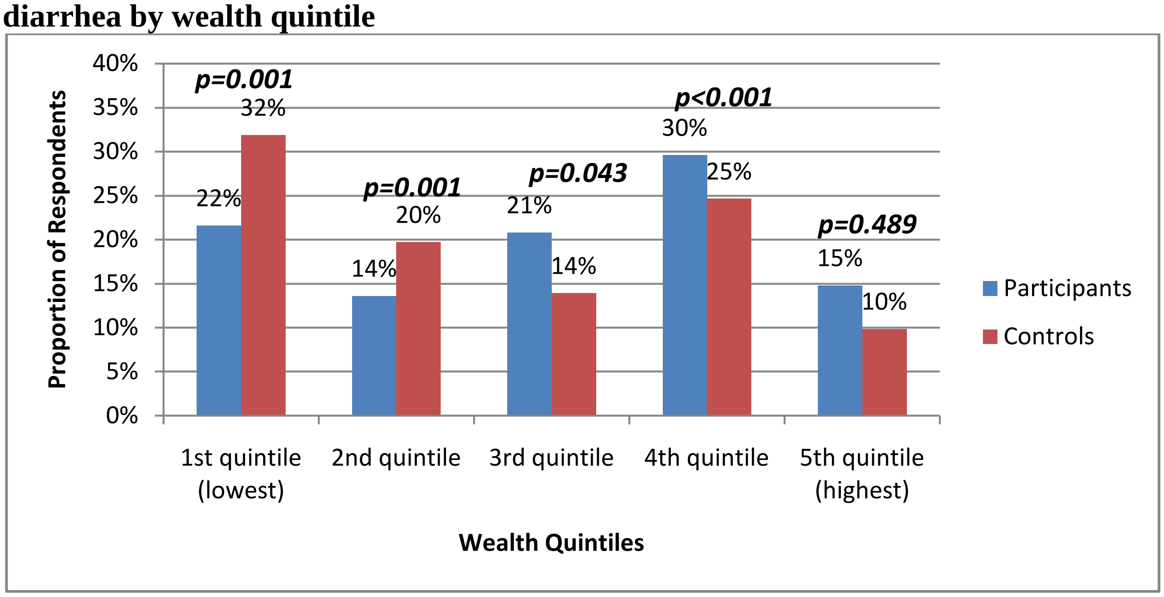
Variable	**Participants**	**Controls**	***p***
Had diarrhea	139/998 (13.9)	449/2138 (21.0)	<0.001
Males who had diarrhea	66/462 (14.3)	201/965 (20.8)	0.003
Females who had diarrhea	73/534 (13.7)	248/1161 (21.4)	<0.001
Children under 5 who had diarrhea	32/102 (31.4)	117/224 (52.2)	0.001
Males under 5 who had diarrhea	16/57 (28.1)	52/106 (49.1)	0.012
Females under 5 who had diarrhea	16/45 (35.6)	65/116 (56.0)	0.020
Had bloody diarrhea	17/981 (1.7)	88/2096 (4.2)	<0.001
Males who had bloody diarrhea	8/458 (1.8)	38/949 (4.0)	0.023
Females who had bloody diarrhea	9/521 (1.7)	50/1135 (4.4)	0.006

Figure 11: Proportion of participants and controls reported to have diarrhea (for all ages and for children under five) and bloody diarrhea



The proportion of participants with diarrhea varied by wealth quintile (Figure 12). Participants in the lowest two quintiles had significantly less diarrhea than controls. Participants in the upper three quintiles had more diarrhea than controls, but the difference between the groups was not significant in the highest quintile.

Figure 12: Proportion of participants and controls who were reported to have diarrhea by wealth quintile



4.3 Multivariate logistic regression models

Regression models were first developed for diarrhea in household members of all ages (Table 6). In the basic model the odds of diarrhea was 39% less for participants than for controls (OR=0.61, 95% CI 0.45, 0.82). When controlling for potential confounders, the odds of diarrhea was 26% less, which was still significant at the alpha level of 0.1 (OR=0.74, 95% CI 0.52-1.05). Presence of household soap and use of a safe storage container were significant in the full model, indicating that these terms may confound the relationship between program participation and diarrheal disease. Although significantly fewer respondents were female in participant than in control households, the gender of the survey respondent was not a significant factor influencing diarrheal disease.

Models for children under five years of age are shown in Table 7. The odds of children having diarrhea in participant households was 57% less than in control households using the basic model (OR=0.43, 95% CI 0.26-0.70) and 55% less using the full model (OR=0.45, 95% CI 0.23-0.86).

Models for respondents with blood in the stools are shown in Table 8. The odds of having diarrhea with blood in the stools was 60% less among participants using the basic model (OR=0.40, 95% CI 0.23-0.70), and 64% less using the full model (OR=0.36, 95% CI 0.20, 0.65).

The restricted models yielded similar results to the basic models with all three outcomes, providing a strong indication that the models were robust. Interactions were tested between program enrollment and presence of soap in the home (Table 9), use of an improved drinking water source (Table 10), safe storage of drinking water (Table 11), and reported use of a latrine (Table 12). There was no evidence that these variables interacted with program participation.

Table 6: Multivariable model assessing the association between program enrollment and diarrheal disease

	Basic model[1]			Full model[2]			Restricted model[2]		
Variable	**OR**	**95% CI**	***p***	**OR**	**95% CI**	***p***	**OR**	**95% CI**	***p***
Program participant (vs. Control)	0.61	0.45-0.82	0.001	0.74	0.52-1.05	0.097	0.58	0.41-0.83	0.002
Gender (Male vs. Female)				0.99	0.70-1.40	0.970			
Wealth index				0.94	0.87-1.02	0.176			
Time to collect water				1.00	1.00-1.00	0.285			
Turbidity (Clear vs. Cloudy)				1.37	0.88-2.13	0.167			
Soap (Present vs. Absent)				0.39	0.27-0.54	<0.001			
Improved drinking water source				0.94	0.64-1.37	0.735			
Safe storage container				0.32	0.13-0.80	0.014			
Latrine used by all household members				1.15	0.69-1.89	0.595			

[1] 3,148 individuals (614 households) were included in the basic model. [2] 2,225 individuals (406 households) were included in the full and restricted models.

Table 7: Multivariable model assessing the association between program enrollment and diarrheal disease among children under 5

	Basic model[1]			Full model[2]			Restricted model[2]		
Variable	**OR**	**95% CI**	***p***	**OR**	**95% CI**	***p***	**OR**	**95% CI**	***p***
Program participant (vs. Control)	0.43	0.26-0.70	0.001	0.45	0.23-0.86	0.016	0.37	0.20-0.68	0.001
Gender (Male vs. Female)				0.61	0.31-1.18	0.142			
Wealth index				0.94	0.80-1.09	0.429			
Time to collect water				1.00	0.99-1.01	0.550			
Turbidity (Clear vs. Cloudy)				1.15	0.42-3.16	0.792			
Soap (Present vs. Absent)				0.68	0.36-1.27	0.229			
Improved drinking water source				0.66	0.32-1.35	0.260			
Safe storage container				0.66	0.20-2.16	0.490			
Latrine used by all household members				0.85	0.34-2.13	0.723			

[1] 328 individuals (240 households) were included in the basic model. [2] 229 individuals (166 households) were included in the full and restricted models.

Table 8: Multivariable model assessing the association between program enrollment and bloody stools

	Basic model[1]			Full model[2]			Restricted model[2]		
Variable	**OR**	**95% CI**	***p***	**OR**	**95% CI**	***p***	**OR**	**95% CI**	***p***
Program participant (vs. Control)	0.40	0.23-0.70	0.001	0.36	0.20-0.65	0.082	0.32	0.18-0.59	0.002
Gender (Male vs. Female)				1.59	0.96-2.62	0.973			
Wealth index				0.87	0.77-0.99	0.252			
Time to collect water				0.99	0.98-1.00	0.331			
Turbidity (Clear vs. Cloudy)				0.97	0.52-1.82	0.126			
Soap (Present vs. Absent)				0.52	0.30-0.92	<0.001			
Improved drinking water source				1.08	0.60-1.94	0.350			
Safe storage container				0.67	0.21-2.11	0.022			
Latrine used by all household members				1.05	0.53-2.05	0.730			

[1] 3089 individuals (611 households) were included in the basic model. [2] 2,182 individuals (404 households) were included in the full and restricted models.

Table 9: Interaction between program participation and having soap present in the household

Variable	**OR**	**95% CI**	***p***
Program participant (vs. Control)	0.75	0.51-1.11	0.155
Soap (Present vs. Absent)	0.32	0.23-0.45	<0.001
Interaction	0.77	0.41-1.46	0.424

Table 10: Interaction between program participation and use of an improved drinking water source

Variable	**OR**	**95% CI**	***p***
Program participant (vs. Control)	0.61	0.43-0.88	0.007
Improved drinking water source	0.88	0.61-1.27	0.509
Interaction	1.00	0.52-1.93	0.993

Table 11: Interaction between program participation and safe storage of drinking water

Variable	OR	95% CI	*p*
Program participant (vs. Control)	0.73	0.53-0.99	0.044
Safe storage of drinking water	0.18	0.04-0.69	0.013
Interaction	1.08	0.20-580	0.932

Table 12: Interaction between program participation and reported use of a household latrine by all family members

Variable	OR	95% CI	*p*
Program participant (vs. Control)	0.53	0.28-1.01	0.053
Latrine used by all household members	0.79	0.55-1.13	0.197
Interaction	1.21	0.58-2.51	0.614

4.4 Summary

Demographics between participants and controls were very similar. Significantly more participants used Gadyen Dlo and believed their water was safe to drink, resulting in significantly less diarrheal disease. Even when adjusting for potential confounders, the odds of diarrhea was 26% less for program participants than for controls. This was an intention-to-treat analysis, where program enrollment was the only criterion for classification as a participant or control rather than reported use of chlorine or confirmed chlorine residual. In this study, 56% of participants and 10% of controls had confirmed positive chlorine residuals, so the long-term health effects of household chlorination were likely underestimated.

Chapter 5: Discussion and Conclusions

5.1 Discussion

This study was an evaluation of the long-term health impact of household chlorination in the JSWF program in the Northwest and Artibonite provinces of Haiti. Program records indicate that over the course of nearly eight years, positive chlorine residuals were detected for 70% of unannounced household visits (Turbes, 2011). Program participants had a 26% reduced odds of diarrhea than controls, and children under five had a 55% reduced odds. Program participation was therefore strongly associated with reduced diarrheal disease. These findings indicate that the JSWF program has achieved long-term behavior change among program participants and resulted in improved health.

This study is one of the first to examine the long-term health impact of household chlorination programs. The health impact of the JSWF program after nearly eight years of operation is consistent with other efficacy studies of household chlorination for shorter time periods. A meta-analysis of household chlorination studies, in which only four studies had a duration of at least one year, found that the risk of diarrhea in children under five was reduced by 40% (Clasen, et al., 2007); another meta-analysis, in which the longest study period considered was 87 weeks and the median length was 20 weeks, found a 29% reduction in the risk of child diarrhea (Arnold & Colford, 2007). The JSWF program, with a 55% reduced odds of diarrhea in children under five after almost eight years of operation, demonstrates that the health impact of household chlorination programs does not diminish over time when consistent chlorine use is maintained.

Several important findings can be elucidated from this study. Since 29% of controls reported using commercial bleach at least once per week, use of chlorine to treat drinking water was common regardless of enrollment in the JSWF program. This was comparable to the 22% of rural households reported to use bleach or PUR to treat their drinking water country-wide (Rosa & Clasen, 2010). Non-program participant households risk using the chlorine inappropriately and thus not receiving the health benefits that come from enrollment in the JSWF program. The water may not be properly treated if they use a bucket without a tap and a lid, add an incorrect chlorine dose, drink the water without waiting thirty minutes, or store the treated water for too long. Education on appropriate use of Gadyen Dlo, in addition to regular household visits and chlorine residual tests, is intended to reduce the likelihood that program participants avoid making these types of mistakes, which non-participant households using commercial bleach could easily make.

The higher proportion of female than male children under five with diarrhea (36% vs. 28% for participants, 56% vs. 49% for controls) suggests that there may be differences in caretaking methods for boys and girls in the JSWF program area that caused more girls to have diarrhea. Male children might be fed more food and kept cleaner than female children, which could lead to improved health. Alternatively, since the majority of survey respondents were female (64% of participants and 74% of controls), it is possible that female respondents were less willing to report or less aware of diarrhea in male children.

Only 37% of participants reported receiving training on the use of Gadyen Dlo from a household visit, which was surprisingly low since DSI aims for technicians to visit each household in the program at least once every six months. Group training at church was reported by 29% of participants and 5% of controls, so information is getting out to people in other formats besides household visits.

Although the proportion of respondents using transparent bottles had many missing observations, if the majority of enrolled participants throughout the program use transparent bottles there is a high risk that the chlorine concentration is reduced in most of these homes. Exposing transparent bottles of chlorine to sunlight can reduce the concentration (Lantagne et al., 2011). If the bottle cap is a different size than that of the program-supplied bottles, then inappropriate dosing is another concern. However, 79% of survey respondents using transparent bottles (not supplied by the program) had positive chorine residuals, indicating that this may not be a concern at this time.

5.2 Limitations and delimitations

There were a number of limitations in this study and observations that need to be discussed regarding its internal and external validity. First, enrollment in the JSWF program was not randomly allocated. Program members consciously made a decision to purchase a bucket from a technician at the clinic or from a reseller to formally enroll in the program. Therefore, there may have been unobservable differences between participants and controls in this study that were inherent to why participants enrolled in the JSWF program in the first place. Survey respondents were randomly selected in order to have a representative sample, but unfortunately any unobservable differences between program participants and controls could not be controlled for.

Control households could not be found for the six randomly selected participant households in Jolivert since nearly all of the households in this village used Gadyen Dlo.

In order to have two control households for each participant household, additional control households from Fond-du-Rock, a nearby village across the river, were surveyed to replace the missing controls from Jolivert. Since participants and controls were comparable, this did not likely impact the results.

If a participant was not home, the enumerators were supposed to return two times to find this person. However, due to logistical and financial limitations, it was not always feasible to send an enumerator back to a village, particularly if it was remote. Enumerators were supposed to walk three houses to the right of each participant household in order to survey the first control household, and three more houses to the right to survey the second control household, but it is likely that this did not always happen. Sometimes the enumerators made mistakes by walking in the wrong direction or walking the wrong number of houses, and sometimes the landscape or environment prevented them from completing their instructions correctly. Furthermore, the enumerators accidentally surveyed some controls without having first surveyed corresponding participants, and in some instances those participants were unable to be completed, leading to an excess number of surveyed controls. Eighty-two control households that did not correspond directly to a participant household were not included in the analysis.

Enumerators asked controls if they were treating their drinking water with Gadyen Dlo, and if they said no they were invited to participate in the study. Although the enumerators were trained to ask the survey questions the same way every time, they did not always ask controls about their participation in the program in the same way. Anyone who had purchased a bucket from the MOL clinic was included as a participant, but controls were anyone who reported that they were not using Gadyen Dlo. This resulted in an inconsistent application of the exclusion policy and decreased the internal validity of the study. Some controls contradicted themselves by initially saying they were not using Gadyen Dlo, but later on in the survey they admitted that they were. It would have been more effective to ask controls to visually inspect the bucket they used to store their drinking water when introducing the survey, and if the bucket was purchased from the JSWF program then they would be excluded and another control would be selected.

Additionally, although 10% of controls had positive chlorine residuals, over a third (39%) did not allow the enumerators to test their drinking water. While program participants are more accustomed to household visits from technicians, the controls may have refused due to unfamiliarity or mistrust of the process. Alternatively, since the vast majority of controls did not have positive chlorine residuals, enumerators may have taken shortcuts by skipping this question for some controls.

5.3 Summary and conclusions

The JSWF program has achieved long-term behavior change and significant diarrheal disease reduction after nearly eight years of operation. It is clear that program participants are making small investments in improving their water quality in the home and having better health outcomes as a result. Although the results of this study may not be directly applicable to household chlorination programs in settings outside the specific geographic area in which the study was conducted, the findings may help inform the development of other programs by demonstrating a working household chlorination model where chlorine sales and usage have been consistently recorded and diarrheal disease reduction has been evaluated.

Chapter 6: Implications and Recommendations

Household chlorination is widely promoted as one of the most cost-effective PoUWT interventions because it is easy to use, able to be produced locally, and scalable. This study found confirmed positive chlorine residuals on unannounced visits among 56% of program participants, and 26% diarrheal disease reduction among participants compared to controls in a long-term household chlorination program.

This study utilized an intention-to-treat analysis, in which participants and controls were included in the analysis based on the records of their program enrollment, regardless of their reported or confirmed use of Gadyen Dlo. Therefore, the estimates of the effect on household chlorination on diarrheal disease may be underestimated compared with the results one would find if a randomized, controlled intervention trial were conducted on the same population. However, the estimates from this study are also more realistic for what may be expected in programmatic settings. A treatment-on-treated analysis will be conducted to determine the effect of household chlorination in the JSWF program, using only participants with confirmed positive chlorine residuals rather than all participants enrolled in the program, on diarrheal disease.

Household chlorination programs should keep careful records of bucket and chlorine sales and household visits to monitor program growth and consistency of use. Regular health impact evaluation studies should be conducted to verify that the program is having a significant reduction in diarrheal disease morbidity. Programs that are considering expansion should plan carefully so that the quality of the services provided remains consistent and that the program remains economically viable. Additional research is needed to support the findings from this study so that the long-term health impact of household chlorination can be understood more fully.

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Appendix A: Principal Component Analysis

Table 13: First component factor scores from principal component analysis

Variable	n	Mean	SD	Factor score
Household construction (dichotomous variables)				
Walls				
Concrete	621	0.65	0.48	0.4057
Tin	621	0.01	0.10	-0.0268
Earthen	621	0.33	0.47	-0.3977
Other	621	0.01	0.08	-0.0487
Floor				
Concrete	622	0.58	0.49	0.3994
Earth	622	0.42	0.49	-0.4045
Other	622	0.00	0.06	0.0331
Roof				
Concrete	622	0.16	0.36	0.2347
Tin	622	0.74	0.44	-0.0607
Other	622	0.10	0.30	-0.2248
Durable assets (continuous variables)				
Number of beds	620	2.40	1.24	0.1676
Number of bicycles	621	0.18	0.48	0.1172
Number of motorcycles	621	0.16	0.50	0.1288
Number of radios	621	0.85	0.94	0.1715
Number of mobiles	621	1.35	1.23	0.1779
Livestock (continuous variables)				
Number of poultry	617	3.54	4.61	-0.0784
Number of donkeys	620	0.49	1.19	-0.0257
Number of cows	620	0.43	1.06	-0.0352
Number of sheep	621	1.69	2.90	-0.0796
Water, sanitation, and hygiene (dichotomous variables)				
Primary drinking water source				
Community tap	621	0.29	0.45	0.1221
Well with pump	621	0.03	0.16	0.0657
Well without pump	621	0.00	0.07	0.0090
River	621	0.32	0.47	-0.0665
Bottled/bagged (sachet) water	621	0.01	0.11	0.0622
Spring/ground source	621	0.28	0.45	-0.1713
Rainwater harvesting	621	0.01	0.08	0.0243
Other	621	0.05	0.22	0.1280
Soap present	573	0.55	0.50	0.0939
Use latrine	566	0.86	0.35	0.1551

Appendix B: IRB Study Exemption Letter

EMORY UNIVERSITY | Institutional Review Board

FROM: Carol Corkran, MPH, CIP
Senior Research Protocol Analyst

TO: Eric Harshfield
Principal Investigator

CC:

Hougendobler	Daniel	Public Health
Myers	Jason	Theology - Main
Null	Alex	Global Health
Turbes	Anna	Pathology - Main

DATE: April 27, 2010

RE: **Notification of Exempt Determination**
IRB00038947
Evaluating the Health Impacts and Human Rights of Access to Household Chlorination in Rural Haiti (Village of Jolivert, northwest Haiti)

Thank you for submitting an application in eIRB. We reviewed the application and determined on **04/27/2010** that it meets the criteria for exemption under 45 CFR 46.101(b)(2) and thus is exempt from further IRB review.

This determination is good indefinitely unless something changes substantively in the project that affects our analysis. The PI is responsible for contacting the IRB for clarification about any substantive changes in the project. Therefore, please do notify us if you plan to:

• Add a cohort of children to a survey or interview project, or to a study involving the observation of public behavior in which the investigators are participating.
• Change the study design so that the project no longer meets the exempt categories (e.g., adding a medical intervention or accessing identifiable and potentially damaging data)

• Make any other kind of change that does not appear in the list below.

Please do not notify us of the following kinds of changes:

• Change in personnel, except for the PI
• Change in location
• Change in number of subjects to be enrolled or age range for adults
• Changes in wording or formatting of data collection instruments that have no substantive impact on the study design

For more information about the exemption categories, please see our Policies & Procedures at www.irb.emory.edu. In future correspondence about this study, please refer to the IRB file number, the name of the Principal Investigator, and the study title. Thank you.

Sincerely,

Carol Corkran, MPH, CIP
Senior Research Protocol Analyst
This letter has been digitally signed

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Appendix C: Household Survey

Deep Springs International Water Chlorination Survey

Good morning / good afternoon. My name is ______. I am part of a team of people who are conducting research on drinking water. The purpose of the study is to understand how the water you drink affects the health of your family. Our team will interview about 600 people in this area. Your house has been selected to participate in the study. If you participate, I will ask you questions about your drinking water and collect a sample of your water. The interview will take approximately 20 minutes. No one except the researcher will know that it was you who provided these answers. Are you willing to participate? If so, I will sign this form to indicate that you are a participant.

HH Number			

____
Person Obtaining Consent

A	Interviewer				
B	Date				
C	Time				
D	Locality				
E	GPS Coordinates	Lat		Long	

Q1.	Circle respondents' gender.	Male	1	Female	0		
Q2.	How old are you?						
Q3.	Did you go to school?	Yes	1	No [GOTO Q5]	0		
Q4.	How many years did you go to school?						
Q5.	Is the male head of house able to read the Bible?	Yes	1	No	0	No male HOH	99
Q6.	Is the female head of house able to read the Bible?	Yes	1	No	0	No female HOH	99
Q7.	OBSERVE: Walls	Concrete	1	Tin	2	Earthen	3
		Other:					
Q8.	OBSERVE: Floor	Concrete	1	Earth	2	Other:	
Q9.	OBSERVE: Roof	Concrete	1	Tin	2	Other:	

Q10. How many of the following does your house own:

				Beds		Bicycles	
Motorcycles		Poultry		Donkeys, horse, oxen		Cows	
Sheep/Goats		Radios		Mobiles			

Q11. What is your religion?

Catholic	1	Protestant	2	Other:

Q12. Do you practice voodoo?

Yes	1	No	2

Q13. What are the ages and genders of the people who live in this house?

I will now ask you some questions about diarrhea. Diarrhea is defined as loose or watery stools three or more times in 24 hours. Which of the household members you mentioned have had diarrhea yesterday or today?

If they had diarrhea, was there blood in the stools?

#	Gender (circle one)	Age	Diarrhea (circle one)	Blood in stools (circle one)
1	M / F		Yes No Don't know	Yes No Don't know
2	M / F		Yes No Don't know	Yes No Don't know
3	M / F		Yes No Don't know	Yes No Don't know
4	M / F		Yes No Don't know	Yes No Don't know
5	M / F		Yes No Don't know	Yes No Don't know
6	M / F		Yes No Don't know	Yes No Don't know
7	M / F		Yes No Don't know	Yes No Don't know
8	M / F		Yes No Don't know	Yes No Don't know
9	M / F		Yes No Don't know	Yes No Don't know
10	M / F		Yes No Don't know	Yes No Don't know

Q14. What is your primary source of drinking water?

Community tap	1	Well with pump	2	Well without pump	3
River	4	Bottled/bagged (sachet) water	5	Spring/Ground source	6
Rainwater harvesting	7	Other:			

Q15. How many times a day does your household collect water? ______

Q16. How long does it take to go to your primary drinking water source, collect water, and come back?

	Minutes

Q17. Can you show me the container you use to collect your drinking water?

Volume		No	0	Don't know		99
Plastic Bucket	1	Gallon container	2	Aluminum can	3	Other:

Q18. Do you believe your current drinking water is safe to drink?

Yes	1	No	0	DK	99

Q19. How do you know if your water is safe to drink **[MA]**?

Water clear	1	Free of bacteria	2	From tap	3
Water warm	4	Other:			

Q20. What about your water makes it not safe to drink **[MA]**?

Water dirty	1	Has bacteria	2	From bad source	3
Floodwater	4	Other:			

Q21. Please tell me all of the different methods for treating water at the household level that you have heard of. ***[Circle the number MA, prompt "any more"].***

Of those methods you mentioned, please tell me if you currently use or have ever used any of those methods and how often you use/used each one. ***[Circle to indicate frequency]***

Type	Heard of	Used
Boiling	1	Never Once Rarely 1/week Daily
Aquatabs	2	Never Once Rarely 1/week Daily
Gadyen Dlo	3	Never Once Rarely 1/week Daily
Dlo Lavi	4	Never Once Rarely 1/week Daily
Add raket	5	Never Once Rarely 1/week Daily
Add citrus	6	Never Once Rarely 1/week Daily
Filter: Type: __	7	Never Once Rarely 1/week Daily
PuR	8	Never Once Rarely 1/week Daily
Other:		Never Once Rarely 1/week Daily

Q22. Have you ever heard of Gadyen Dlo?

Yes	1	No [GOTO Q41]	0	DK [GOTO Q41]	99

Q23. Where have you heard of Gadyen Dlo **[MA]**?

Radio	1	Printed ads	2	Resellers	3
Relatives/friends	4	Technician	5	Other:	

Q24. Do your friends or neighbors use Gadyen Dlo?

Yes	1	No	0	DK	99

Q25. Do your relatives use Gadyen Dlo?

Yes	1	No	0	DK	99

Q26. Have you ever used Gadyen Dlo?

Yes	1	No [GOTO Q28]	0	DK [GOTO Q28]	99

Q27. Are you using Gadyen Dlo now?

Yes	1	No	0	DK	99

Q28. Why do you/would you use Gadyen Dlo [MA]?

Cleans water	1	Prevents disease	2	Instructed to do	3
Other:					

Q29. Why do you/ would you not use Gadyen Dlo [MA]?

Water clean	1	Don't like smell	2	Don't like taste	3
Ran out	4	Can't afford it	5	Other:	

Q30. Have you received any training on Gadyen Dlo? If so, what types? **[MA, prompt 'any more']**

How many times did you receive that training? Who gave it?

Type	Received	No.	Who gave? (circle or write in)
Poster/pamphlet	1		Technician Other:
Household visit	2		Technician Other:
Group training at church	3		Technician Other:
Group training other than church	4		Technician Other:
Other:	5		Technician Other:
None [GOTO 32]	6		

Q31. Did you receive enough training about Gadyen Dlo?

Yes	1	No	0	DK	99

Q32. How many days ago did you last purchase Gadyen Dlo?

	Days

Q33. Where did you purchase it from?

Health facility	1	Resellers	2	Other:

Q34. How many bottles did you purchase?

	Bottles

Q35. May I see the bottle you are using now?

	mL	No	0

Q35opacity. Mark transparency of bottle .

Transparent	1	Not transparent	2

Q36. When was the last time you treated your water with Gadyen Dlo?

Today/yesterday	1	In the last week	2	In the last month	3	Rarely	4
Only once	4	Never	5	DK	6		

Q37. Can you show me the container you use to treat the water with Gadyen Dlo?

Volume		No	0	Don't know	99
Jerry Can	1	Plastic Bucket	2	Bucket with tap	3
Other:					

Q38. How many caps do you add to what volume of water?

	Caps		Clear Water Volume	DK	99
	Caps		Turbid Water Volume	DK	99

Q39. How long do you wait to drink the water after it is treated with Gadyen Dlo?

	Minutes

Q40. For what do you use the water you treat with Gadyen Dlo? **[MA, prompt 'any more']**

Drinking	1	Cooking	2	Bathing	3
Washing hands	4	Washing dishes	5	Washing clothes	6
Washing fruits/vegetables	7	Other:			

Q41.

Q41.a What do you do when someone in your house has diarrhea **[MA]**?		Q41.b How do you get there (circle all that apply)?							Q41.c How much does it cost to get there (circle gouds or dollars)?	
Visit health facility	1	Walk	1	Mule	2	Tap-tap	3	Other:		Gouds / Dollars
Visit traditional healer	2	Walk	1	Mule	2	Tap-tap	3	Other:		Gouds / Dollars
Treat at home	3									
Other:	4	Walk	1	Mule	2	Tap-tap	3	Other:		Gouds / Dollars
Nothing	5									

Q42. May I see your current drinking water?

Q42.a From what source is this water?	Q42.b Circle primary drinking water?	Q42.c How many gallons is the storage container?	Q42.d Is it covered?		Q42.e What container is it in?	Q42.f Is the water treated?		Q42.g How many hours ago did you treat it?
			Yes	No		Yes	No [GOTO 43]	
	1		1	0		1	0	
	2		1	0		1	0	

Q42.a

Community tap	1	Well without pump	2	Well with pump	3
River	4	Bottled/bagged (sachet) water	5	Spring/Ground source	6
Rainwater harvesting	7	Other:			

Q42.e

Bucket	1	Bucket with tap	2	Other:

Q43. Can you please give me a small glass of drinking water? TEST for chlorine residual.

	mg/L	No	0

Q44. OBSERVE water and circle all that apply:

Clear	1	Cloudy	0

Q45. May I see your soap for washing hands?

Soap present	1	Soap absent	2	Refuse	99

Q46. Where do children usually use the bathroom?

Latrine	1	Yard	2	Ground outside yard	3	Other:

Q47. Can you show me where you usually use the bathroom? [FINISH]

Latrine present	1	Latrine absent	2	Refuse	99

Thank you very much!