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Anna Turbes Date

Evaluating the Long-Term Consistency of Purchase and Use in a Household Chlorination Program in Rural Haiti

By

Anna Turbes

Master of Public Health

Hubert Department of Global Health

_____

Clair Null, PhD

Committee Chair

_____

Daniele Lantagne, PhD, PE

Committee Member

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By

Anna Turbes

Bachelor of Arts

College of Saint Benedict

2004

Thesis Committee Chair: Clair Null, PhD

An abstract of

A thesis submitted to the Faculty of the
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Abstract

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By Anna Turbes

Background: Fifty percent of rural Haitians lack access to an improved water source, exposing them to diarrheal disease, which is a leading cause of death in children. The Jolivert Safe Water for Families (JSWF) program has provided safe water to rural Haitians since 2002 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; and, 5) conduct unannounced household visits to monitor chlorine use and provide ongoing education.

Objective: There is significant criticism in the current research regarding the long-term sustainability of water chlorination programs. The published research makes conclusions based on data from programs in existence for 5 years or less; this study examined the long-term take-up of JSWF program based on 8 years of sales records and household visits.

Methods: Hand-written program records that included chlorine purchases and results of unannounced chlorine residual tests were transcribed into an Excel document. Study participants for the health evaluation were randomly selected from the program records.

Results: The JSWF program enrolled 4,609 households in 186 communities and sold 47,862 bottles of chlorine between September 2002 and May 2010 - enough to treat about 11.5 million gallons of water. Various inacuracies were discovered in the program records, therefore analysis was restricted to the program area with the most accurate records (n=1,304). A total of 64.0% (n=835) of participants had at least one recorded chlorine purchase and 57.3% (n=747) had multiple recorded purchases. More than 20% of participants made enough purchases to treat all of their drinking water in a given year. Overall, 77.3% (n=2,733) of the unannounced chlorine residual tests conducted were positive, indicating the presence of chlorine in the water.

Discussion: After 8 years of program operation, the number of participants and communities continues to expand, though the quality of the data prevented a definite conclusion to be made regarding the long-term consistency of chlorine purchase and use in the JSWF. However, the data analysis on the participants that live near Jolivert showed consistent purchases and positive chlorine residual tests.

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Chapter 1: Introduction

1.1 Background

Haiti has the highest rates of infant and under 5 mortality in the western hemisphere and diarrhea is one of the leading causes of death (UNICEF, 2006), accounting for 18% of all deaths among children under 5 years old (Bryce, 2005).

Contaminated water is a primary route of disease transmission; 12% of the population has a piped water source while 37% of all people in Haiti and 50% of people in rural Haiti lack access to an improved drinking water source (UNICEF and WHO, 2010). If a population does not have access to an improved water source or household connection, they are obligated to collect their water for daily use from an open source, which means that virtually the entire population is at risk for water contamination between the source and point-of-use, as the viruses, bacteria, and protozoa that cause diarrheal disease can enter the water between the time it is collected and when it is consumed (Wright, et al, 2004 and Clasen, et al, 2009). Contaminated hands and flies and animals that come into contact with the drinking water are common routes of contamination.

As Robert Tauxe of the Centers for Disease Control and Prevention (CDC) stated, "Water is often collected from sources of dubious quality, hauled over a distance, and stored in the home before it is consumed," which provides many opportunities for contamination (Global Issues in Water, Sanitation and Health, 2009). A number of studies have shown that stored household water can contain higher levels of microbial contamination than source water (Wright, et al, 2004). When people use contaminated water for drinking, cooking and other household activities, they are more prone to infection as fecal matter and other forms of contamination can easily be transmitted from hands to stored water (Pickering, 2010).

There is some knowledge of water chlorination in Haiti as 21% of Haitians self-report use of bleach in their drinking water as a treatment method (MSPP, 2007). However, 76% of Haitians report they use nothing to treat their water.

Although it has been proven that the proper administration of chlorine can eliminate many waterborne diseases, some researchers argue that even though point-of-use water treatment is a low cost intervention, it may not be effective in the long-term if people do not use the treatments consistently (Sobey, et al, 2008). One study stated there is evidence that these programs can reach a large population, but that persistent use is not common and that acceptability studies show that uptake is less common among poor and uneducated people, which are the populations with the highest risk of disease (Schmidt and Cairncross, 2008).

There is still much debate surrounding the overall effectiveness of water chlorination programs due to the lack of information on the consistency of use among program participants over time. The research done on home water chlorination to date has only evaluated programs that have been in existence for five years or less; this goal of this research is to examine the long-term sustainability of a water chlorination program based on longitudinal data collected from the records of a household water chlorination program in existence for over eight years.

The analysis focuses on program records that provide information on the amount and frequency of chlorine purchases for each participating household as well as the results of chlorine residuals tests performed on their drinking water by the program. Analysis from the chlorine sales and home visit records will provide information to the program regarding its effectiveness and allow it to make modifications, if needed, before expanding the program. The analysis will also provide general information regarding long-term program adherence, which may be applicable to other programs. This

information is necessary for programs and institutions to make educated decisions regarding the scaling up or discontinuation of point-of-use water chlorination programs around the world.

Despite an impressive set of program records, during analysis it became apparent that not all of the records were of the same quality. Although the inconsistencies in program records lead to inconclusive results regarding the consistency of chlorine use for the program as a whole, analysis could still be performed on a subset of communities with presumably accurate records. Additionally, the goal of the thesis evolved to include analysis of the feasibility of a large-scale water chlorination program in terms of effectiveness and sustainability.

1.2 Significance

Since more than 3 billion people worldwide must gather water for daily needs from non-networked sources such as rivers, ponds, and wells, point-of-use (POU) water treatment has become a popular method used to treat water (UNICEF, 2008). POU treatment is a method used to treat water at the point-of-consumption to limit contamination. This method has withstood many field tests and has been shown to enhance the health of its users and provide a way to target the households that do not have access to networked water sources (Mintz, et al, 2001). There have been several systematic reviews and field trials that have found a reduction of diarrheal disease up to 40% among people who employ home water treatment methods (Arnold and Colford, 2007, Clasen, et al, 2007, and Fewtrell, et al, 2005), though there are researchers that argue that without other concurrent environmental changes, such a decrease in diarrheal disease would not have been observed since although disease is transmitted through water, it is not the only route of transmission (Eisenburg, et al, 2007 and Kirchhoff, et al, 1985).

The Centers for Disease Control and Prevention (CDC) has shown that household water chlorination is effective at killing pathogens (Kasper, 2007) and has designed a “Safe Water System” (SWS) intervention that combines household point-of-use water chlorination, household education and a simple

environmental improvement of proper water storage to improve water quality. The system has a proven health benefit shown by a reduction of diarrhea prevalence by 22-84% among users (CDC, 2008b and Arnold and Colford, 2007). A meta-analysis of 21 studies found a pooled risk reduction of 29% (relative risk, 0.71; 0.58-0.87) among programs employing water chlorination projects (Arnold and Colford, 2007). SWS projects have been implemented on five continents and in over 20 countries (CDC, 2006).

1.3 Introduction to the Jolivert Safe Water for Families Program

The SWS project operating in Haiti is called Jolivert Safe Water for Families (JSWF) and was started in 2002 with the mission of providing a sustainable water treatment method for the citizens of northwest Haiti to decrease the burden of diarrheal disease. Missions of Love, Inc. (MOL), a faith-based NGO from Kentucky, operates a health clinic in Jolivert, which is a rural community located about 20 kilometers south of Port-de-Paix on the Les Trois River (marked with a red star on the map below). MOL established the JSWF program with internal funding, private donations, and assistance from the CDC and USAID.

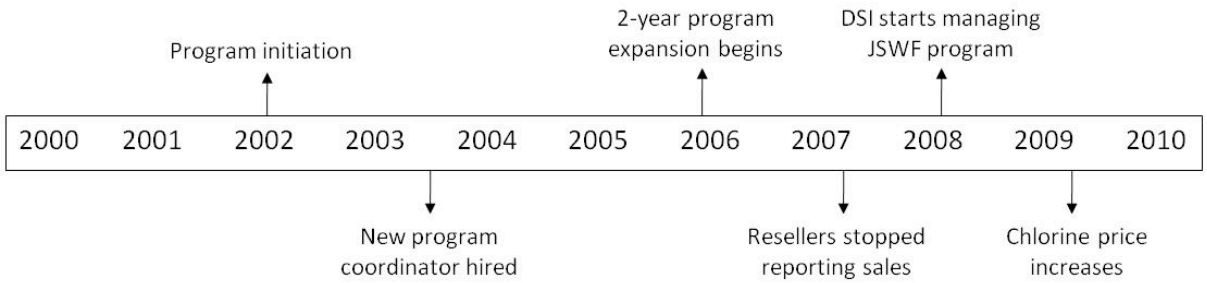
In 2007, Deep Springs International (DSI) took over the JSWF program and continues to manage it while expanding the program to other areas of Haiti (Ritter, 2008).

Figure 1: Map of Haiti

http://geology.com/world/haiti-satellite-image.shtml

The JSWF project started with just 200 pilot families in 2002 in and around Jolivert and has grown to include more than 4,700 households. Due to demand, the program underwent an expansion from 2006-2008 with a $20,000 USAID grant (Ritter, 2008). Over the course of eight years, the program has expanded to include 185 communities reaching from Port-au-Prince in the south past Port-au-Paix in the north. The timeline below outlines the history of the JSWF program.

Figure 2: JSWF Program Timeline



Although Jolivert was not in the area of Haiti affected by the earthquake on January 12, 2010, the disaster may have caused a small increase in program participants secondary to northern migration of earthquake victims. Over the last three years of analysis, average yearly program growth has been 8.73%. During the first five months of 2010 the program had already reached 6.6% growth, which would equate to 15.84% growth over 12 months, which may indicate growth due to immigration into the program area after the earthquake.

Additionally, the data for this thesis was collected before the outbreak of cholera at the end of 2010 , which resulted in a quadrupling of the number of participants in the program.

1.3.1 JSWF Operations

The JSWF program makes and sells chlorine in the same location the local medical clinic is located. The program employs a Haitian supervisor, program coordinator and two technicians. The supervisor is employed by MOL but provides support to JSWF and is responsible for tabulating monthly and yearly sales as well as communicating with DSI (which is located south of Port-au-Prince in the city of Leogane).

The project coordinator enrolls new program participants and sells chlorine from a table in front of the clinic. If a patient comes to the clinic with recurrent diarrheal disease, parasites or malnutrition, the nurses formally recommend that the family start treating their water with chlorine. As they exit the clinic, the program coordinator is able to sell families the chlorine as well as educate the purchaser on proper use. Although the program receives many new participants from health clinic referrals, it is open to anyone and expands based on word-of-mouth.

When a new household is enrolled in the JSWF program, it receives a bucket with a unique number. The bucket follows the CDC Safe Water System guidelines for water storage and therefore has a tap and a lid in order to prevent recontamination of the water after the chlorine treatment.

The new household can purchase the subsidized bucket from the program, or they can bring their own bucket with a lid and for a small fee the program will drill a hole and insert a tap. The bucket with a tap is an item that is desired by many people in the area; it was found that many households entered the program to receive a bucket with no intention of participating in the water chlorination aspect. It is assumed that the households that have a recorded date that they received a bucket with no record of a chlorine purchase or household visit fall into this category (n=1,278; 27.7% of recorded participants).

Figure 3: SWS bucket with tap and lid

Photo source: author

Figure 4: JSWF branded program bucket manufactured in Haiti

Photo source: author

In addition to enrollment, chlorine sales and education, the program coordinator is responsible for recording all chlorine and bucket sales for each program participant and overseeing program expenses and project supplies.

The technicians are trained to make the hypochlorite solution, called *Gadyen Dlo*, using a generator at the program headquarters in Jolivert and are also responsible for performing unannounced household visits to each program participant every six months (though with program expansion, this goal became unattainable; this topic is presented in the discussion section). Chlorine residual tests are performed during visits to check for evidence of chlorine in the participant's drinking water, indicating that they are using the hypochlorite solution.

Figure 5: Hypochlorite production by JSWF program staff in Jolivert

Photo source: author

The chlorine residual tests indicate if the household added enough chlorine to protect them against the majority of bacteria and viruses that can cause diarrheal disease and if there is enough chlorine to protect the water from recontamination while it is stored (CDC, 2008a). To determine if the water is protected from recontamination, the technicians test for "free chlorine" in the water, which measures the amount of chlorine that remains available in the water to act as a disinfectant.

The technicians use a color-wheel test kit to measure free chlorine residual. They add the household's drinking water to a test tube, then empty a packet of pre-measured powder chemical DPD (N,N diethyl-p-phenylene diamine) (CDC, 2008a). If the water turns pink, free chlorine is present. The shade of pink corresponds to a numeric free chlorine value, which should be within 0 to 2.0 milligrams of chlorine per liter of water.

Figure 6: Color wheel test kit

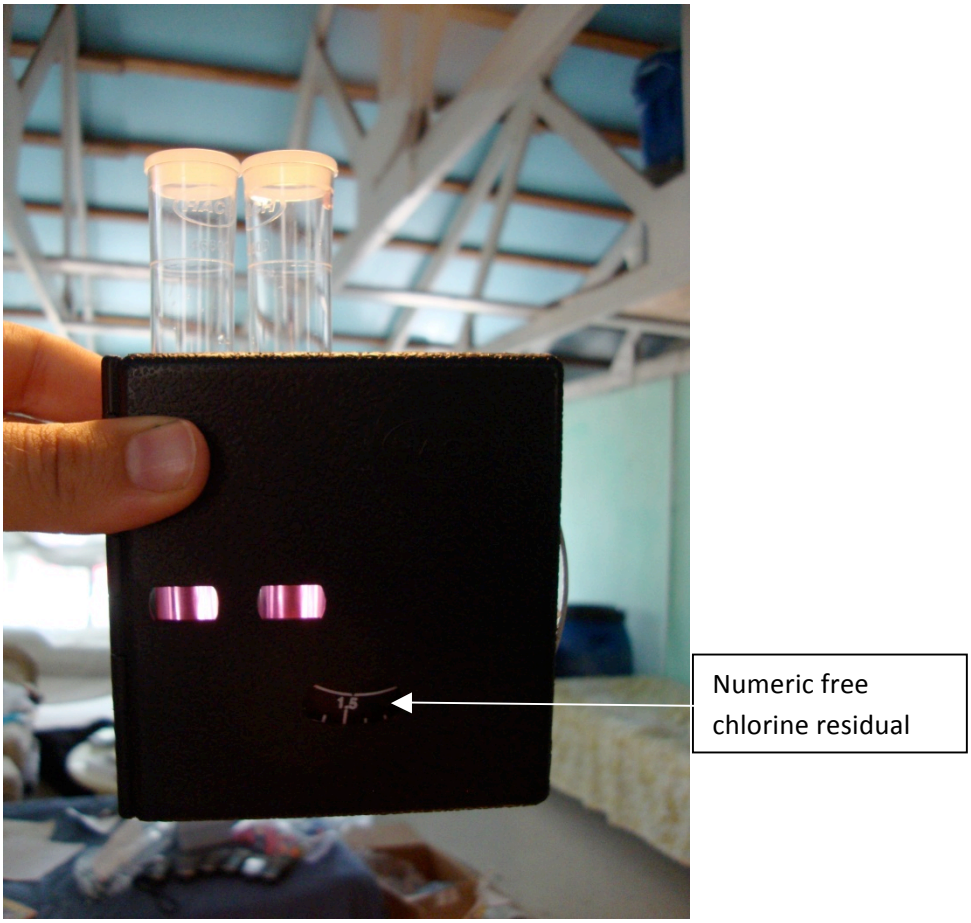


Photo source: author

The results of the chlorine residual tests are recorded at program headquarters. During the household visits, the technicians may also provide ongoing education to program participants or fix broken buckets, which is also recorded in the program records.

Chapter 2: Literature Review

2.1 Point-of-Use Treatment Methods

There are two main categories of point-of-use (POU) water treatment methods: disinfection and filtration (Sobsey, et al 2008). Water disinfection can be done by chemical use, which includes chlorination and coagulant-chlorine systems, or heat, which includes solar disinfection (SODIS) and boiling. The two main types of filtration systems are ceramic filters and biosand filters which rely on physical removal of pathogens from the water.

All of these methods have been shown to reduce diarrheal disease and the concentration of pathogens in water, but they each have their advantages and disadvantages. Table 1 outlines the various water treatment methods and their respective costs, benefits and drawbacks.

Table 1: Water treatment methods

Method	Mode of Action	Cost	Benefits	Drawbacks
Chlorine	Add hypochlorite solution to water with low turbidity and wait 30 minutes before use	US $0.25 to treat 1,000 gallons of water	Easy to understand, can be produced in country	Does not treat turbid water; may be associated with bad taste
Filtration	Water is filtered therefore removing organic contaminants and can treat 20-60L of water per hour	Ceramic: US $8-30 Biosand: US $50-100 (Kasper, 2007)	Socially desirable, can be used with turbid water	Expensive, hard to replace parts
SODIS	Solar water disinfection of non-turbid water in transparent plastic bottles; bottles left in the sun for a minimum of 6 hours	Free (except the cost of the bottles)	Easy to understand	6 hour delay; need sun (may not be as effective in rainy seasons)
Coagulation/ Flocculation	Chemical coagulant is added to water which coagulates particles, water is then agitated to form larger clumps that can then be physically removed with a filter	US $0.10 to treat 10 liters of water (Kasper, 2007)	Rids the water of visible particles, can be used with turbid water	Requires three steps: coagulation, agitation and filtration
Boiling	Water is boiled to kill any pathogens in the water	Depends on area and boiling method (wood or gas fires)	Immediate treatment	Can be very expensive and time consuming, especially if firewood needs to be carried to the house

Water chlorination has proven effective against most bacteria and parasites, though is not as effective against protozoa, especially *Crysptosporidium parvum,* which are resistant to chlorine (Kasper, 2007 and CDC, 2008a). Additionally, chlorination is most effective when used in water with low turbidity, therefore it is best for use in communities that do not have turbid water or have a way to reduce the water's turbidity. The CDC widely promotes water chlorination in conjunction with safe storage around

the world and it costs US $0.25 to treat 1,000 gallons of water (Kasper, 2007 and Sobsey, et al, 2008). Reduction in diarrheal disease by 29% was found in a meta-analysis of 21 relevant studies with no reported evidence of publication bias (Arnold and Colford, 2007). When separating out the studies, sub group analyses revealed that water storage in covered vessels and education also provided a protective effect (Arnold and Colford, 2007).

In an independent analysis of the SWS in Jolivert, Haiti (POU chlorination plus safe water storage), it was found that people enrolled in the program had 10-20 times less bacteria in their water than people not in the program (Brin, 2003). The analysis also demonstrated a 60% reduction in diarrheal disease, which was correlated with positive chlorine residual tests, compared with a 40% reduction among all program participants (consistent users versus non-consistent users) (Brin, 2003).

All of the current POU treatment methods are effective, but they vary in their sustainability. Sobsey, et al, 2008, provide the following list as key components of a sustainable POU system:

Able to consistently produce sufficient quantities of microbiologically safe water to meet daily household needs:

1. *Effective for treating many different water sources and quality levels including turbid and high organic content waters*
2. *Requires relatively small user time to treat water*
3. *Low cost; …not causing households to stop treating water because they cannot afford to purchase the technology or continuously replace it*
4. *Have a reliable, accessible and affordable supply chain for needed replacement units or parts for which consumers are willing and able to pay*
5. *Maintain high post-implementation use levels after cessation of intensive surveillance and education efforts, as in field trials and marketing campaigns.*

These criteria were provided in an article that argued in favor for filtration systems as the most effective solution for providing clean water to those who need it in the developing world. It has been argued that water filtration systems are beneficial because the user is solely responsible for a single payment (Sobsey, et al, 2008). The thought being that the user will not interrupt their water treatment if their income changes or they cannot purchase chlorine due to travel difficulties or other constraints. However, treatment of water with filtration systems may be interrupted if the system breaks and replacement parts are not attainable.

Many communities that rely on POU water treatment do not have the logistical ability to support supply chain delivery of the technologies that Sobsey, et al argue are necessary for a POU treatment program (Lantagne, et al, 2009). Additionally, setting aside the argument of *future* technology reaching these communities, there are communities in Haiti where water filtration systems were previously promoted and given to residents who now find themselves lacking replacement parts.

Although the authors concluded that filtration systems were the most effective and sustainable way to treat water based on the ranking system they developed, Lantagne et al argue that there are flaws in their ranking system that if considered, would show that water chlorination and other POU water treatment options meets their criteria, depending on the context.

Water chlorination programs are capable of addressing all of the components listed above, but are limited in their ability to treat turbid water. It is also argued that there is not sustained post-implementation use, but there are no long-term follow up studies done to date.

For this reason, critics have questioned the true long-term sustainability of water chlorination programs arguing that people lose interest in the programs and therefore usage declines, the health impact becomes negligible and the programs become too expensive to maintain. Sobsey, et al state that although water chlorination decreases diarrheal disease and improves water quality, those effects last

only months and do not address long term sustainability and "continued technology performance in homes and communities" based on their ranking system which was developed based on water quality, water quantity, cost and supply chain.

2.2 Limitations of Water Chlorination Program Studies

One of the major limitations of studies that examine the effectiveness of chlorination is the low number of blinded studies. Arnold and Colford performed a meta analysis and acknowledge a major limitation of their analysis was that all of the outcomes were reported by participants, and only one of the studies was blinded which could bias the reduction in diarrheal disease away from the null. The single blinded study found that there was no difference between chlorine users and non-users (Arnold and Colford, 2007).

As briefly mentioned above, the concern is that among blinded studies the reduction in diarrheal disease is not as significant as unblinded trials report. Schmidt and Cairncross (2009) published a 7% reduction in diarrheal disease among chlorine users in two blinded studies compared to 43-44% reduction in unblinded studies. However, Clasen et al point out that although the subjective outcomes may have biased the study, there is still a protective effect of 30% after adjusting for the pooled effect (Clasen, et al, 2009). The difference in effect is contributed to the placebo effect and courtesy bias since users knew that a reduction in diarrheal disease was the desired outcome from the education they received. In order to combat this, there is an argument towards using more objective outcomes to measure diarrheal disease incidence, such as hospital or clinic visits.

2.3 Consistency of Use

Although there have been an abundance of studies that have examined the efficacy of POU chlorination, there is very little data on the long-term consistency of use of household chlorination. The question

now is even though significant health impacts have been shown in short trials; do they really persist over time?

One hypothesis suggests that habit-forming behaviors and technical mastery of the intervention takes time, and therefore adherence and health outcomes may be found to be greater after a longer follow-up period (Luby, et al, 2004). Acceptability studies commonly find that poor and uneducated populations have a lower uptake of interventions, and they are the same populations that are at highest risk of disease (Clasen, et al, 2009). However, since it can be argued that these populations may take a longer time to adopt new behaviors, it is possible that the follow-up periods of most studies to date (five years or less since program introduction) are too short to illustrate the potential behavior change in these populations (Clasen, et al, 2009).

In contrast, some argue that program participants lose interest in the intervention over time which would therefore lead to lower compliance, and eventually, abandonment of the intervention making the impact of the intervention lower over longer follow-up periods (Arnold and Colford, 2007).

Arnold and Colford performed a systematic review of 21 studies with a short median study length of 30 weeks and it was found that there is a decreased efficacy of water chlorination programs with longer intervention length, but this result was not statistically significant. These authors and others make a call for future studies to look at multi-year follow-up to examine long-term acceptability and sustainability of water chlorination interventions to examine whether the large heath impacts observed in shorter studies can be seen over longer periods (Arnold and Colford, 2007). In their meta-analysis, the median length of study was six months and the longer trials showed gradual attenuation in the reduction of diarrheal disease. However, the programs in the analysis that showed higher compliance through positive chlorine residual tests showed higher diarrheal disease reduction than other programs.

Additionally, many of the studies performed on the effects of water chlorination are efficacy studies that examine the health outcomes. It has been proven that chlorinating the water reduces diarrheal disease, but the studies are unable to truthfully examine household adoption of the product. In most studies, researchers are available to replace materials such as chlorine or water storage materials if needed, and are there to answer questions as they arise. When this is the case, these are not true indictors of how a sustainable, long-term program operates and thus cannot be relied upon to provide information on long-term behavior change.

As stated above, becoming a consistent chlorine user may take time, especially since it may take many seasons for the participant to see the true health benefits of the program because as it has been noted, there may be seasonal differences in disease reduction (Luby, et al, 2004). Additionally, in short-term studies, the users are not asked to make a decision as they are assigned to a case or control group. In a long-term project, the users must make the decision to participate in the program, which shows a different level of motivation to be a consistent user.

2.4 Measuring Use

The following are three suggested measurements that can be used to assess behavior change surrounding HWT: volume of sales, amount of water treated and the percentage of households effectively treating their water (Hernandez, 2007).

The volume of sales can easily be calculated for most water filtration systems by counting the number systems sold and for chlorination or chemical disinfection programs based on the amount of chemical sold, but would be difficult for SODIS or boiling treatment methods.

The volume of water treated is easier for chlorination programs than the others since it can be calculated based on the volume of sales. Although there is no way to know if a household is only treating their drinking water or if they are treating all of their stored water, but an estimate can be

made based on purchases. This measurement is more difficult to measure for filtration and other disinfection systems since regular purchases are not necessary.

Measuring the percentage of households effectively treating their water could be done for all methods by testing the water for presence of bacteria and other microbes. For the SWS, effective treatment is based on the presence of chlorine residual in the household's drinking water and the presence of a covered container that contains a spigot or other narrow opening for water removal in order to reduce recontamination.

2.5 Documented Use

It is important to note that there have been successful water chlorination programs around the world. The following are four case studies, which represent four different countries on three continents. Each of the programs is unique, but all of them associate consistent use with effective marketing and social acceptance. Additionally, three of the programs followed survey participants for at least one year and the participants all elected to start using chlorine, which demonstrates motivation to continue use of the product.

Kenya

CARE and Population Services International (PSI) increased access to SWS in Kenya that included education and chlorine sales (Parker, et al, 2006). The program started with implementation by CARE in 2000 and in 2003 PSI branded the chlorine solution "WaterGuard" which was sold in the commercial sector. Nurses in a maternal and child health clinic were trained in the use of this chlorine and the steps of proper hand-washing, which they taught to their clients at clinic visits. The clients received follow-up surveys and free-chlorine residuals were performed two weeks and one year after they were trained on water chlorination and hand-washing (Parker, et al, 2006).

At two weeks, 68% of the 186 participants tested positive for free chlorine residual in their drinking water. Among those who tested positive, 69% reported purchasing a bottle of "WaterGuard" after the education session. The following were reasons given for purchasing chlorine, in order of frequency of response: felt it was important to treat water, diarrhea prevention, unclean water, ease of use and less expensive than current method (Parker, et al, 2006).

Among the households that had negative chlorine residual tests, the most common response was that they had no "WaterGuard" in their home. Other reasons given for not chlorinating the water was that they used another treatment method, they did not have enough money to buy the product, or they did not like the smell or taste of chlorinated water. There was no significant difference in socioeconomic status between households that had positive or negative chlorine residuals (Parker, et al, 2006).

At the one-year follow-up survey, only 51 households were surveyed, but 71% of them had detectable chlorine residuals, indicating behavior change (Parker, et al, 2006).

Zambia

In Zambia, the SWS was introduced in 1998 and coupled with marketing of chlorine branded as "Clorin" by PSI (Olembo, et al, 2004). Program evaluation six years after the start of the program indicated that primary water handlers who were older than 20 years old and those with secondary education were more likely to use "Clorin." It was also found that households that lived in areas of active promotion of chlorine were more likely to use based on self-reported use. Additionally, the most important factor leading participants to start using "Clorin" was use by a neighbor (Olembo, et al, 2004).

Chlorine residual was tested in the households that reported using "Clorin." The results are below, in table 2, and indicate that consistent use of chlorine increased with length of time in the program. However, after adjusting for housing and social marketing factors, the differences seen between groups

were not statistically significant (Olembo, et al, 2004). Although a single test does not provide information on consistency of use, it gives cross-sectional information regarding use in the community.

Table 2: Chlorine residual tests from "Clorin" program evaluation (Olembo, et al, 2004)

Duration of use (n)	Positive chlorine residual
< 6 months (230)	20.0%
6-12 months (150)	27.3%
> 12 months (166)	36.1%

An independent agency conducted a cross-sectional study that included unannounced visits to households in the program area and reported that only 13.5% of households had positive chlorine residual tests (Olembo, et al, 2004). Although this appears to be a low percentage of chlorine users, it is a statistic representing the entire population in the survey area. Among reported users of “Clorin” in the survey (527, 42%), positive residuals were found in 36% of households (Olembo, et al, 2004).

Another study in Zambia used motivational interviewing as a technique for increasing chlorine adoption and consistent use. Based on positive chlorine residual tests, they observed compliance of 71.1-91.4% over an 8-week period (Thevos, et al, 2000).

During a follow-up survey 9 weeks after implementation, 96.9% of participants reported using chlorine to disinfect water, and 90% stated that they intended to continue water treatment (Thevos, et al, 2000). The participants that did not intend to continue using chlorine said it was due to a lack of funds (Thevos, et al, 2000). At the time of the survey, observations were made by the enumerators to judge the

compliance with instructions for disinfectant and found than 99% kept the solution out of the sun and 98% knew the correct dosage (Thevos, et al, 2000).

Bolivia

In Bolivia, a case-control intervention that promoted POU water disinfection, safe storage and education conducted monthly visits to 64 intervention households for six months (Quick, et al, 1999). During the initial visit, 71% of the households had detectable chlorine residual and on the final visit 95% of the households had detectable residual. However, only 64% had positive residual tests in conjunction with usage of their safe water storage vessel (Quick, et al, 1999).

One could argue, though, that the study participants were expecting monthly visits and therefore had motivation to treat the water since they were held accountable or that they were only treating their water when they knew they were going to receive a visit. Additionally, chlorine was delivered weekly to intervention households and was coupled with education about the product (Quick, et al, 1999).

Pakistan

A two-year study in Pakistan found that some households were more consistent chlorine users than others (Luby, et al, 2004). Families with higher socioeconomic status were more likely to start using chlorine, even though the study provided it free of charge to all participating families. However, there is conflicting evidence regarding whether or not socioeconomic status, education level and age have an impact on use (Luby, et al, 2004, Olembo, et al, 2004, and Quick, et al, 1999).

It was also found that late adopters in the communities are generally the community members with the worst health outcomes and lower socioeconomic statuses, but the researchers add that finding early adopters who like the product can aid in social acceptability (Luby, et al, 2004). However, knowing that

the target population may take a longer time to reach is important when considering that many studies do not provide sufficient time for people to enter the program and become consistent users.

Two separate groups were studied, one in 2000 and one in 2001; however, 51 (64%) of the households studied in 2000 also participated in 2001. Follow-up for the group studied in 2000 indicated a 41% reduction in diarrheal disease and a 73% reduction was seen in the group studied in 2001 (Luby, et al, 2004). Although this study did not measure chlorine residual, it was assumed that the chlorine was being used correctly since there was a reduction in diarrheal disease.

Haiti

Previous research on the JSWF program was performed in 2007 by Michael Ritter, a 2008 graduate of Rollins School of Public Health. He examined the sales data from the program from September 2002 through April 2007 and conducted a cross-sectional survey of 357 chlorine users (people who had made at least one chlorine purchase recorded by the program) compared to 170 non-users (those who had never made a purchase). Analysis was done both on consistency and the rate of purchases.

Ritter found that being a chlorine user was associated with wealth, believing that treating water with chlorine prevents diarrheal disease, belief in one's ablity to make their water safe, support from others, and a perception that water treatment is the norm in the community. Additionally, household visits from program technicians and encouragment from community members to treat water resulted in more consistent chlorine purchases and an increased rate of purchases.

Barriers to using chlorine included increased travel costs and distance from a sales site and inability to purchase a program bucket (safe water system bucket with lid and tap).

Ritter recommended that the JSWF lower the cost of water storage containers for people in lower socioeconomic statuses, establish more sales sites in remote areas, and start behavior change

campaigns focusing on self-efficacy and social norms of water treatment to improve the consistency and rate of POU water chlorination in program areas.

There are many options for water treatment in the developing world, and each has its own strengths and weaknesses. POU water chlorination provides an inexpensive, easy treatment method for low turbidity water and there is plentiful data supporting the effectiveness of this treatment method, but there are conflicting opinions and data regarding its effectiveness over time. There have been very few blinded trials of water chlorination and most studies last only weeks to months and are therefore unable to determine the long-term impact of these programs. There has been documented chlorine adoption in different programs around the world, but there is still a need for data on the long-term consistency of use in POU water chlorination programs.

Chapter 3: Methodology

3.1 Population and sample

The study was conducted in Jolivert, a rural community in the northwest province of Haiti, but included data from participating households within the JSWF geographic region. Participating households are defined as entries in the program books that have a name, bucket number, or address with a purchase record. The communities that the program serves are of varying size and while some are considered urban, most are rural. The largest city with program participants has 185,000 residents (Population Totale, 2009) and the smallest rural sites have less than 200 residents, according to program staff.

The population also widely varies in their proximity to the program headquarters, ranging from living within the compound where the program headquarters are located to total round trip times exceeding 5 hours (based on estimates from the program coordinator).

All entries in the program books were included in the initial data collection. Each book was recorded line for line in an Excel document. The records obtained from this population are unique in the fact that careful records have been kept for eight years, which provides an excellent source of data to analyze the success of a long term point-of-use water chlorination program in terms of sustainability, accessibility, and consistency of use.

The local project coordinator is responsible for keeping the books up to date with sales information, technician visits to the households and any identifying information such as street name or other landmark where the house is located.

These records were analyzed for trends in chlorine sales, household visits, and other variables that indicate the level of consistent use of chlorine at the household level. Additionally, in May and June 2010 there was a household survey completed for 201 program households. The data from the survey was merged with the sales database in order to examine the household's knowledge and perceptions of the project with their purchase and visit history. The information from the survey was also used to provide information on the accuracy of the program records.

3.2 Sales Database Data Collection

There are over 100 books that are organized by community. In general, there is one book per community, but if the community is large or close to the Jolivert program headquarters, it often contains multiple books due to the large number of participants. Each page begins with the participant's name on the top of their page and their bucket number(s). When a household enters the program, they are required to have a bucket with a lid and a tap, which is available for purchase. However, each family can elect to bring their own bucket instead of purchasing one from the program. Those families would then pay a small fee to have a tap drilled in by the technicians and the program coordinator would write a unique number on the side of the bucket (which all of the buckets for purchase from the program contained).

The participant's name and bucket number are followed by any information about the location of their house and a telephone number if applicable. After these identifiers, the dates that the participant purchased chlorine and the amount they purchased are listed chronologically.

To the side of the individual sales records, there is a column to record household visits done by the two program technicians, though there is no way to distinguish which technician performed the visit. The

data is recorded along with the result of a chlorine residual test; if a test could not be performed, the reason would be denoted next to the date. Common reasons for not doing a chlorine residual test include: no water, no one was home or there was a mechanical problem with the program bucket that needed to be fixed.

Figure 7: Program paper records

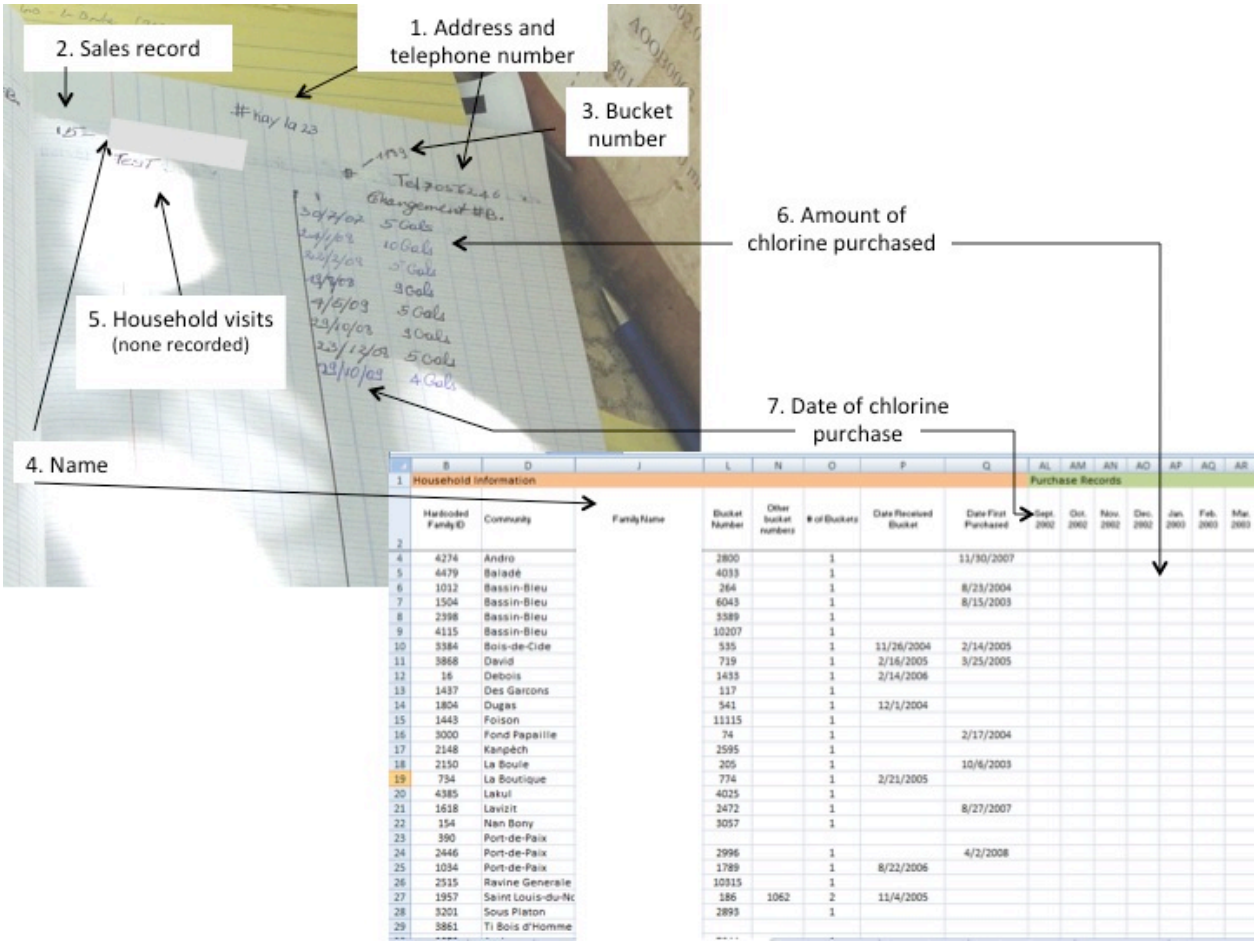
Box of program books, organized by community

The data on the pages include the following (demonstrated below in figure 8):

1. An address or household location (some households also had telephone numbers)
2. Number indicating the sales record; chronologically given, each community has its own series of numbers
3. Bucket number
4. Name of the person who purchased a bucket (covered in the photograph to preserve confidentiality)
5. Dates and results of household visits

6. Quantity of chlorine purchased
7. Dates of chlorine purchases

Figure 8: Household record



The results of the chlorine residual tests were written as "+" or "-" if the test was completed. If a person received a "+", it meant that they had chlorine residuals greater than 0.1 milligrams per liter in their drinking water. If a chlorine residual test was unable to be completed, a reason was given. For data

entry, chlorine residual tests and reasons for not performing a test were all transcribed into numbers as follows:

0 = negative chlorine residual in stored water

1 = positive chlorine residual in stored water

2 = no member of the household was home, therefore the technician could not enter to perform the residual test

3 = hardware visit; on a visit to a house, the technician was made aware of a maintenance problem with the bucket, no residual test was done

4 = hardware visit; program participant came to the clinic to have their bucket repaired (counted as a visit since the participant had contact with a technician)

5 = no drinking water was stored in the house, therefore a chlorine residual test could not be performed

6 = household moved or left program (no longer wanted to participate or passed away)

7 = education visit, no chlorine residual test was done

The data from the household visits were recorded in the Excel spreadsheet in a separate section to the right of household visit data (see figure 8).

After entering the information from the books, further information was gathered from the program coordinator about the locations and activity of the current and former resellers. There have been 32 resellers involved with the program since initiation, but at the time of the survey there were only 21 active resellers. The current resellers were identified by the program coordinator and are also identified in the sales records due to the large quantities of chlorine purchases.

Additionally, there is one community organization that purchases large volumes of chlorine to sell to community participants. This organization was identified based on the recorded name ("association") and is treated as a reseller in the analysis.

3.2.1 Resellers

Most participants only purchase chlorine for their household, but some participants elect to become resellers. These individuals are often community leaders or store owners that elect to make large purchases of chlorine from the Jolivert headquarters, which they sell for double what they paid for it in order to make a profit and to cover transportation costs.

The resellers originally kept records for the program with information regarding who purchased chlorine from them and how many bottles they purchased. When this was being done, the program was able to confidently record which participants were purchasing chlorine. However, starting in 2007, the majority of resellers began keeping less accurate records and some stopped reporting sales to JSWF. Although no data was collected specifically concerning this decline in reporting, program staff has been told by the resellers that keeping track of sales was too much work that did not benefit their business.

At the time of research, there were eight resellers keeping accurate records according to the program coordinator, or which six of them operated in communities close to Jolivert and have more contact with the program staff.

So although the records can provide an idea of how the program is operating, they are not complete. In many cases the records only indicate a name, partially due to the fact that there is no way to account for all of the participant's purchase records, especially those who live in distant communities and rely on resellers for chlorine purchases. When there is only a name listed, it is most likely because they

received a bucket but never had follow-up (a recorded purchase or household visit), however this cannot be verified. It is suspected that many of these participants never intended to be a part of the program; as the bucket with a cover and a tap was coveted commodity that people were willing to purchase for their home without a desire to participate in the chlorination program.

3.2.2 Database Analysis

Much of the analysis separated communities based on distance. The Jolivert clinic area includes the communities in and very near to Jolivert (within a 10 minute walk). The Bassin-Bleu area includes the town of Bassin-Bleu and the communities surrounding it, all of which lie within five kilometers of Jolivert. The communities in the grouping of "less than one hour" are further than five kilometers, but less than an hour based on travel time from Jolivert. The remaining households received the categorization of "greater than one hour."

3.3 Household Survey

A randomized survey of 201 program participants was completed in May and June of 2010. The survey goal was to obtain information on diarrheal disease reduction, knowledge of "Gadyen Dlo" chlorine and proper use, training, and determinants of use. One Haitian survey coordinator and five additional Haitian enumerators were trained on survey administration and performing chlorine residual tests.

3.3.1 Selection of chlorine user households:

All households/chlorine purchasers were entered into an Excel document along with their respective community name. Purchasers were excluded from random selection if they had any of the following characteristics:

- Group: church, school, NGO, hospital, etc.
- Households in communities outside the target area

    - More than 3 hour drive
    - More than 1 hour walk after transport
    - 200 HD or more in transportation
- Households with missing names or communities
- Households that started purchasing chlorine three months prior to the survey (March 2010 – May 2010)

From the remaining eligible households, 300 were randomly selected to be surveyed (enough households to ensure the goal of surveying 200 participant households, the remaining 100 acted as alternates, explained below).

The enumerators were given a list of which houses to survey. If there was no one present to respond to the survey the first time the household was visited, the enumerator returned later in the day. If still no one was available, the enumerator returned to the same household the following day. If the survey could not be completed after three visits, the enumerator was given a alternate randomly selected household to survey. Additionally, if the selected household refused to participate or if the family had moved outside the survey area or to an unknown location, an alternate was selected by the research team.

3.3.2 Selection of control households

In the front of the randomly selected chlorine user household, the enumerator walked to the right and selected the third and sixth houses in that direction, to survey. When visiting the household, the enumerator asked if they used Gadyen Dlo. If they did, another house was selected. If they did not use Gadyen Dlo, they were included in the survey if consent was obtained. If there was no one from the selected household available to respond, the enumerator visited the household one more time later in the day. If still a survey still could not be completed, they turned to the right in front of the house and

walked in that direction and selected the third household to survey. If the head of household refused to participate, another household was selected by continuing in that direction and choosing the third household. The same criteria from above applied to this new household.

For more information on the household survey, see Harshfield, 2011.

3.4 Plans for data analysis

Although all entries in the program books were entered into Excel, some were excluded for analysis. There were initially 4,704 entries and the following were the criteria for exclusion:

- Name listed with no bucket number and no purchase record or recorded technician visit (120 excluded for this reason).
- No name and no purchase record (community listed). A total of 85 entries were excluded for this reason. This could happen when resellers or community groups purchase chlorine and give the program coordinator an estimate of the number of families in the area that are purchasing chlorine. It is always the program coordinator's intention to get the names of the individuals, but that is not always possible, especially in more remote communities.
- Purchase record with no name, community name or bucket number. These purchases were summed by date in order to do validity checks and were a single entry in the Excel document.

Resellers were excluded from portions of the analysis and analyzed separately (32 records).

After applying the exclusion criteria, data analysis on sales and visit records will be performed on 4,609 entries that include 4,578 participants and 32 resellers.

The data from the paper records was analyzed to look at the consistency of chlorine use among participants from the beginning of the program in September 2002 to May 2010 to see if there are any

trends in use (seasonal, yearly, by community, etc). Additionally, program participants will be categorized as “regular,” “sometimes,” or “non-users” based on the consistency of their purchase records.

The data from the books was also combined with the survey data to examine the determinants of chlorine use and adoption and to look at the differences between participants and non-participants and other factors that may predict consistent use.

Chapter 4: Results

4.1 Program Records Summary

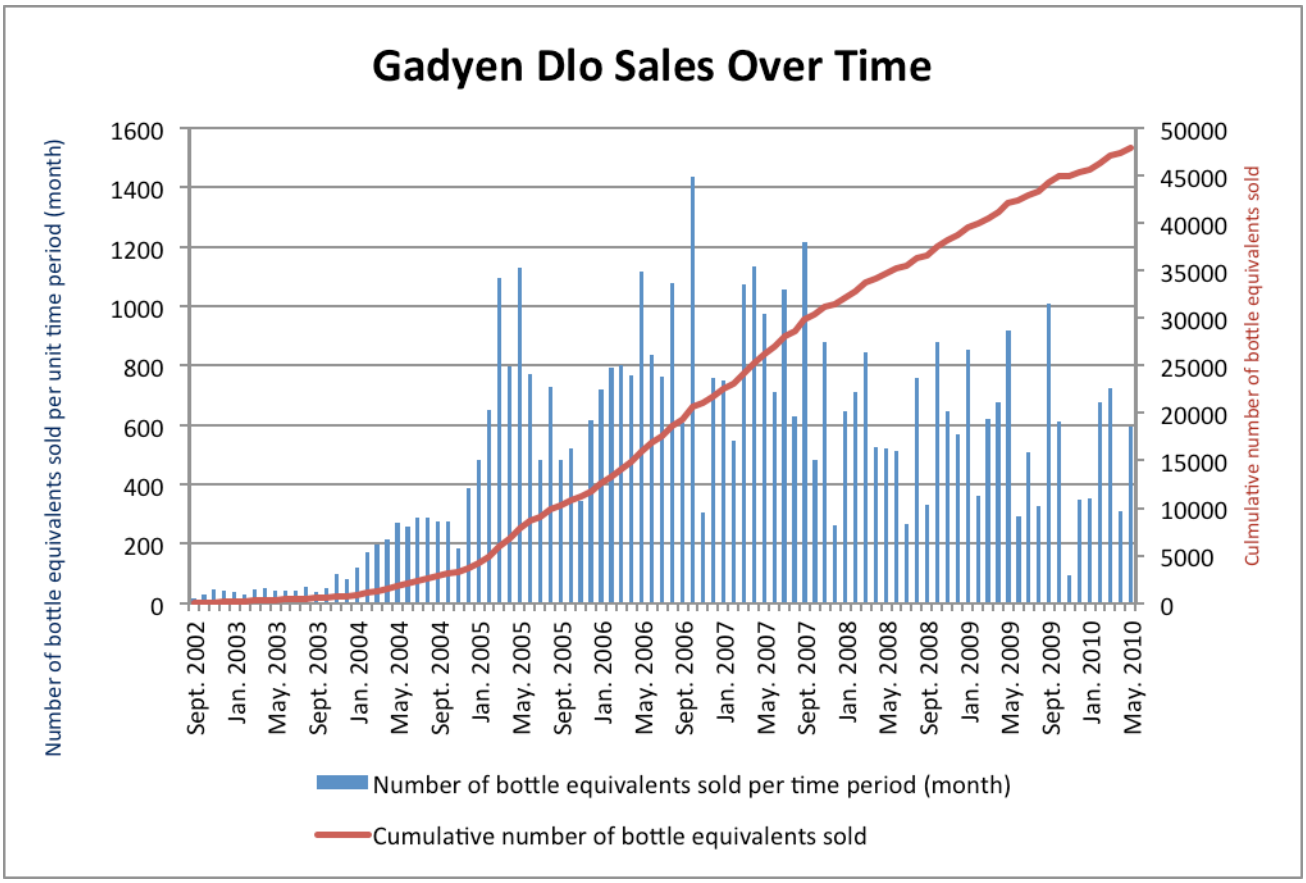
4.1.1 Chlorine Sales

There have been 47,861.5 bottle equivalents of chlorine sold since 2002, which is enough to treat 11.5 million gallons of water. The total number of bottles sold averages to 10.4 bottles per family enrolled in the program or 25.3 bottles per household that has at least one chlorine purchase recorded. Each bottle of chlorine treats 240 gallons of water (42 treatments per bottle, each treatment disinfects five gallons of water).

Of the 4,609 observations included in analysis, 40.7% (n=1,876) have at least one recorded chlorine purchase. When only examining the households with at least one purchase, 89.9% (n=1,649) households have multiple purchases, although this group accounts for only 35.8% of the entire program population.

The last quarter of the year, October through December, historically has the lowest average sales, which are about 22.9% lower than the third quarter, and the highest sales are from April to June, which somewhat overlaps with the rainy season which lasts from May to July.

Figure 9: Gadyen Dlo sales over time*



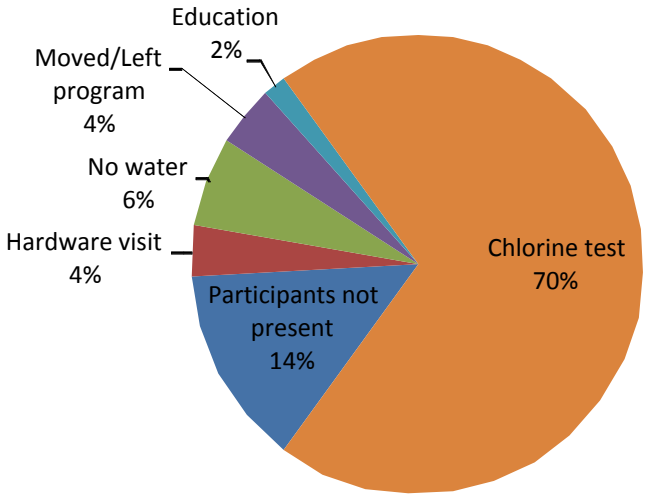
*Calculations based on program sales records.

4.1.2 Household Visits

The first recorded household visit was in the second quarter of 2003, six months after the program started. On average, the program technicians completed 83.8 household visits per month, ranging from 0 to 359 in a given month, which averages to 1.6 visits per program participant. However, many households, especially those located more than one hour from Jolivert, never received a visit (n=2,928, 63.5%). When only considering households that received at least one visit, the average was 4.1 total visits per household.

A total of 7,037 visits were completed, of which 4,926 (70.0%) resulted in free chlorine residual tests. Reasons for not completing a chlorine test can be seen below in Figure 10.

Figure 10: Outcomes of household visits



4.1.3 Chlorine Residual Tests

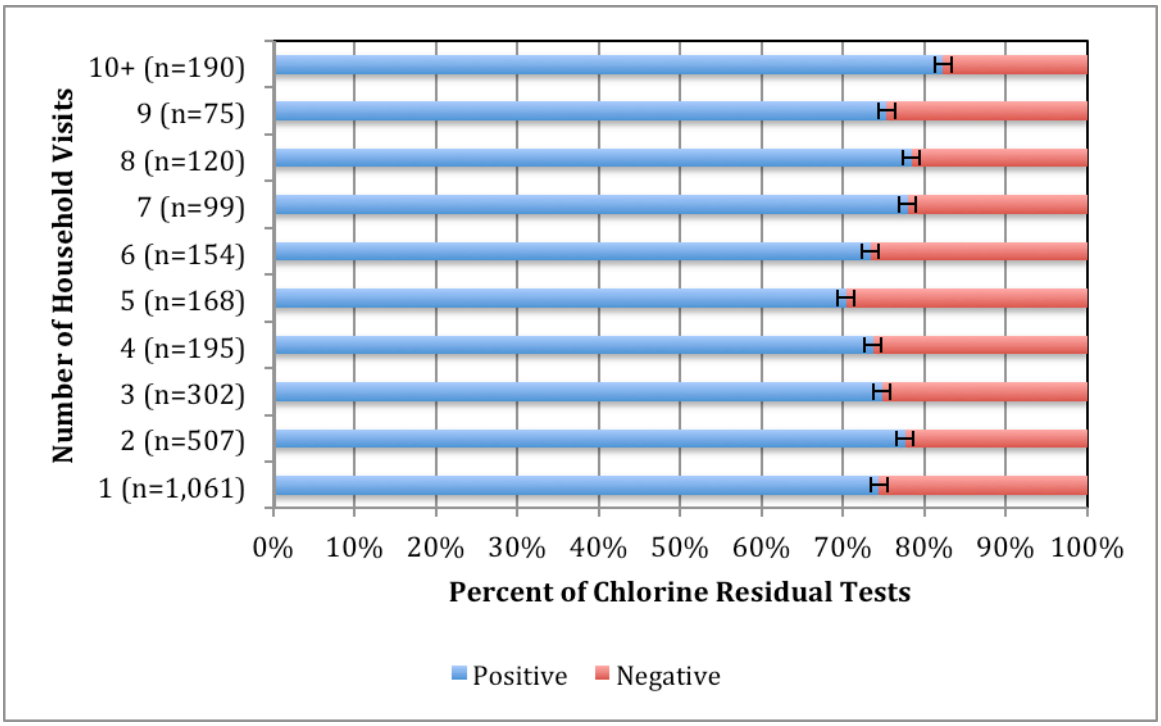
Overall, 70.0% (n=4,926) of all unannounced household visits resulted in chlorine residual tests of which 77.5% (n=3,782) were positive, indicating 0.2 mg/L of chlorine in their drinking water or greater (which is noted as a pink color change by the technicians). Results of the household visits and chlorine residual tests are demonstrated in Table 3.

Table 3: Household visits and chlorine residual tests

Variable	n (%)
Total unique program participants	4,609 (100.0%)
Never received a visit	2,928 (63.5%)
Ever received a visit	1,681 (36.5%)
Ever received a chlorine test	1,385 (82.4%)
Never received a chlorine test	191 (11.4%)
Total number of household visits	7,037 (100.0%)
Total visits that didn't result in chlorine test	2,111 (30.0%)
Total visits that resulted in chlorine tests	4,926 (70.0%)
Positive	3,891 (77.5%)
Negative	1,035 (22.5%)
Total number of chlorine tests among HHs that received at least 3 tests	3,924 (100.0%)
Minimum, maximum and median # tests	3, 16, 5
Positive	3,028 (77.2%)
Negative	896 (22.8%)
Overall percent of positive residual tests	
Number of unique households (min, max, median # tests)	
<=33%	39 (4, 14, 7)
34-66%	113 (3, 16, 8)
67-99%	269 (3, 16, 9)
100%	220 (3, 16, 6)

Overall, 34% (n=220) of participants that received at least three chlorine residual tests had a positive result every time. Only 6% (n=39) of those with at least three tests had less than one third of their tests result in positive residual. Figure 11 demonstrates the average percent of positive and negative chlorine residual tests based on the number of household visits.

Figure 11: Percent of positive chlorine residual tests by number of visits with a chlorine residual test



4.1.4 Distance

Program participants that live one-hour or less from program headquarters received significantly more household visits than participants that live more than one hour from the program ($p<0.001$). Overall, 50.4% (n=2,321) of all program participants live within one hour of Jolivert and consequently receive 3.8 times more household visits than those who live one to two hours away and 8.83 times more visits than those who live more than two hours from Jolivert.

Table 4, below, demonstrates the difference in the number and rate of visits based on the community's distance from Jolivert. A total of 239 participants that received a household visit did not have a start date (date they received program bucket or made their first chlorine purchase) recorded and therefore did not contribute to the average rate of visit calculation.

Table 4: Household visits by distance

Community	Size of Community n (%)	Number of Visits n (%)	Average Rate of Visit per Number of Months in Program
All communities	4,609 (100%)	7,037 (100%)	0.05
Jolivert clinic area	259 (5.6%)	1,322 (18.8%)	0.09
Bassin-Bleu area	1,045 (22.7%)	3,554 (50.5%)	0.08
<1 hour from Jolivert	1,017 (22.1%)	1,478(21.0%)	0.04
>1 hour from Jolivert	2,184 (47.4%)	683 (9.7%)	0.03
Missing distance	104 (2.3%)	0 (0.0%)	0.00

Of the 2,348 participants that have a program start date, 42.5% (n=999) never received a visit. The average rate of visits in all communities under consideration is equivalent to less than one visit per year.

Households that received more home visits by technicians had significantly higher percentages of positive chlorine residual tests ($p<0.001$). Those that received a rate of less than one visit per year in the program had a significantly lower average of positive chlorine residual tests (67.6%) compared to households that averaged more than two visits per year in the program (79.4%) ($p<0.001$).

A total of 90.3% (n=6,354) of the household visits were performed within one hour of Jolivert, although only 50.4% (n=2,321) of program participants live in that area. As seen in the table 4 above, Jolivert and its surrounding communities (excluding the nearby Bassin-Bleu area) only make up 5.6% of the program population yet they received nearly 20% of all household visits.

The relationship between the distance of a community from the JSWF program and the household visit coverage by year is recorded below in Table 5. Each row identifies a program area and each column

represents a specific year of the program. The goal for the program technicians is to visit each participating household every six months.

Table 5: Household visits and chlorine residual tests by geographic location and year

		Total number of visits, unique households visited (% households visited) Total number of chlorine residual tests (% positive)		
		2005	**2007**	**2009**
Row	**Total**			
1	Jolivert clinic area	385, 150 (89.8%) 180 (72.2%)	385, 32 (17.3%) 25 (92.0%)	294, 170 (82.5%) 232 (90.1%)
2	Bassin-Bleu area	707, 331 (73.6%) 493 (78.5%)	347, 281 (47.4%) 271 (79.0%)	603, 457 (69.8%) 457 (82.9%)
3	<1 hour from Jolivert clinic	309, 166 (53.9%) 220 (85.0%)	50, 48 (9.0%) 25 (72.0%)	307, 254 (42.4%) 194 (73.7%)
4	>1 hour from Jolivert clinic	122, 100 (23.1%) 98 (83.7%)	164, 149 (19.9%) 117 (82.1%)	96, 90 (10.4%) 41 (51.2%)
	Total	1,523, 747 (54.8%) 991 (79.3%)	946, 510 (24.7%) 438 (80.1%)	1,300, 971 (41.8%) 924 (81.4%)

In the column for 2005, the Jolivert and Bassin-Bleu program areas have at least a two to one ratio of household visits to unique households, while the communities in rows three and four have lower ratios (1.86:1 in row 3 and 1.22:1 in row 4). This indicates that in 2005 the technicians were not able to reach their goal of two visits per household in a calendar year in the communities located further from Jolivert. The technicians did not reach the goal of providing a household visit to every participant in any of the communities, but they were closest to reaching that goal in Jolivert in 2005 with 89.8% of the households visited.

As the program grew in size, 2007 and 2009 both had a higher proportion of visits to unique households compared to 2005. In 2009, 74.7% of all visits were to households that received a single visit compared

to 49.0% of the visits in 2005. As the number of program participants increased, the technicians were unable to maintain the goal of visiting each household two times per year in the Jolivert and Bassin-Bleu areas and the percentage of households who received at least one visit declined in all community areas.

There is a decrease in total visits in 2007, despite a 63.3% increase in the number of participants.

In 2005 and 2009 technicians visited a higher percentage of households in the Jolivert clinic area than in any of the other areas despite having the fewest number of program participants.

The second line in each box in Table 5 demonstrates the number of chlorine residual tests and the percentage of them that were positive. In 2005, row 4, the percentage of positive chlorine residual tests is higher than in communities closer to Jolivert, though it declines over time. However, there are also fewer chlorine tests completed in communities more than one hour from Jolivert (n=378) compared with communities within one hour (n=4,493), which may result in a less accurate portrayal of positive residual tests than the percentages seen in rows 1, 2 and 3.

4.1.5 Program Growth

When looking program growth, only participants that have a recorded chlorine purchase or household visit were included in the analysis (n=2,361). A total of 2,248 participants were dropped from analysis; 970 participants were dropped because they had no bucket, recorded purchase or visit and 1,278 participants were dropped because they had a bucket but no recorded chlorine purchase or household visit. Table 6 examines program growth by looking at program statistics during three different years.

Table 6: Program growth over time

	2005	2007	2009
Total participants*§	1,363	2,063	2,323
Active participants**	812	627	602
Total bottles sold	8,038.5	9,712	6,619
Total bottles sold to resellers	692	4,725	3,302
Total visits	1,522	593	1,300
Number of households visited	747	511	971
Number of households with chlorine residual tests	573	382	720
Number of chlorine residual tests	991	438	924
Number of communities with at least 5 participants*	84	96	100
Number of participants in communities with at least 5 participants*	1,363 (100%)	2,063 (100%)	2,323 (100%)
Jolivert clinic area	167 (12%)	185 (9%)	206 (9%)
Bassin-Bleu area	450 (33%)	593 (29%)	655 (28%)
<= 1 hour from Jolivert clinic	314 (23%)	536 (26%)	599 (26%)
> 1 hour from Jolivert clinic	432 (32%)	749 (36%)	863 (37%)

* Cumulative calculations. There are an additional 86 communities with fewer than 5 participants, 41 of which have only 1 participant.
** An active participant is defined as a household that received a new bucket, had recorded purchase, or had a recorded household visit in the stated year or the year before.
§ 2,170 entries excluded because they do not have a recorded start date determined by the date they received a program bucket or the first recorded chlorine purchase.

The program started with just 200 participants in 2002 and as seen on the top line of Table 6, the number of participants nearly doubled between 2005 and 2009; however the growth rate was slower between 2007 and 2009, increasing by only 12% between those years.

Through May 2010, there were 4,609 households listed in program records, of which only 3,374 (73.2%) have a recorded bucket number and 1,915 (41.6%) have a recorded chlorine purchase.

The communities listed in the table are those with known start dates, which are calculated by the first date a participant from their respective community received a bucket number or made a chlorine

purchase. There are a total of 182 communities in program records, 69 of which do not have a start date. Of the 182 communities listed, 43 (23.6%) communities have only one household and 82 (45.1%) communities have less than five households; in 2006, 2007 and 2008, communities with fewer than five participants made up 50% or more of the new communities.

Of the 69 communities that do not have a recorded start date, 52 (75.4%) of them have fewer than five households. A total of 39 (75.0%) of these 52 communities are greater than one-hour travel from the Jolivert clinic or have missing data on distance. Distance information was collected from the program staff and missing data can be interpreted as greater than one-hour travel since the staff, who frequently travel in the area, were not familiar with the communities.

4.2 Data Validity

4.2.1 Previous JSWF Research

In 2007, a Rollins School of Public Health student, Michael Ritter, wrote his thesis on the Jolivert Safe Water for Families program and the determinants of consistent chlorine use. At the time of his research, the program had 2,142 program participants, of which 2,098 (97.9%) had a recorded bucket, purchase or household visit. Additionally, there were 4,794 household visits completed, averaging 1.45 visits per household enrolled in the program. 3,158 (65.8%) of the household visits had water samples taken for free chlorine residual tests of which 2,432 (77.0%) were positive (Ritter and Lantagne, 2011).

The goal of this thesis was to continue Ritter's research and use the program records to see if there was evidence of long-term consistent behavior change among program participants. At the time of Ritter's research, the program staff was keeping consistent records for both household visits and chlorine sales. However, between 2007 and 2010, there was a rapid increase in recorded program participants and the

staff was unable to continue keeping reliable records. The change in the accuracy of the records over time is demonstrated in the following sections, by: 1) comparing the monthly financial and paper records; 2) examining the impact of resellers on sales; 3) comparing the results of the survey to program records; and 4) looking at the growing distance of participating households and its impact on recorded sales.

4.2.2 Monthly Financial Records and Paper Records

To investigate the accuracy of the household paper records kept by program staff, the paper records (where bucket number, chlorine purchases and household visits are recorded for each household) were compared to the monthly financial report generated by the program administrator that summarizes the total number of bottle equivalents sold. Results are shown below in Table 7.

Table 7: Discrepancy of sales between sales database and program financial records

	2006	**2007**	**2008***	**2009****	**2010*****
Sales database recorded sales (bottles)	10,583	9,712	7,862	7,847	6,374
Monthly financial reports recorded sales (bottle equivalents)	13,234	10,292	8,190	8,624	8,057
Percent of bottles from monthly financial reports unaccounted for	20.0%	5.6%	4.0%	9.0%	20.9%

*Monthly financial reports missing for one month. Data from the 11 months with complete data was used to extrapolate for the missing months.

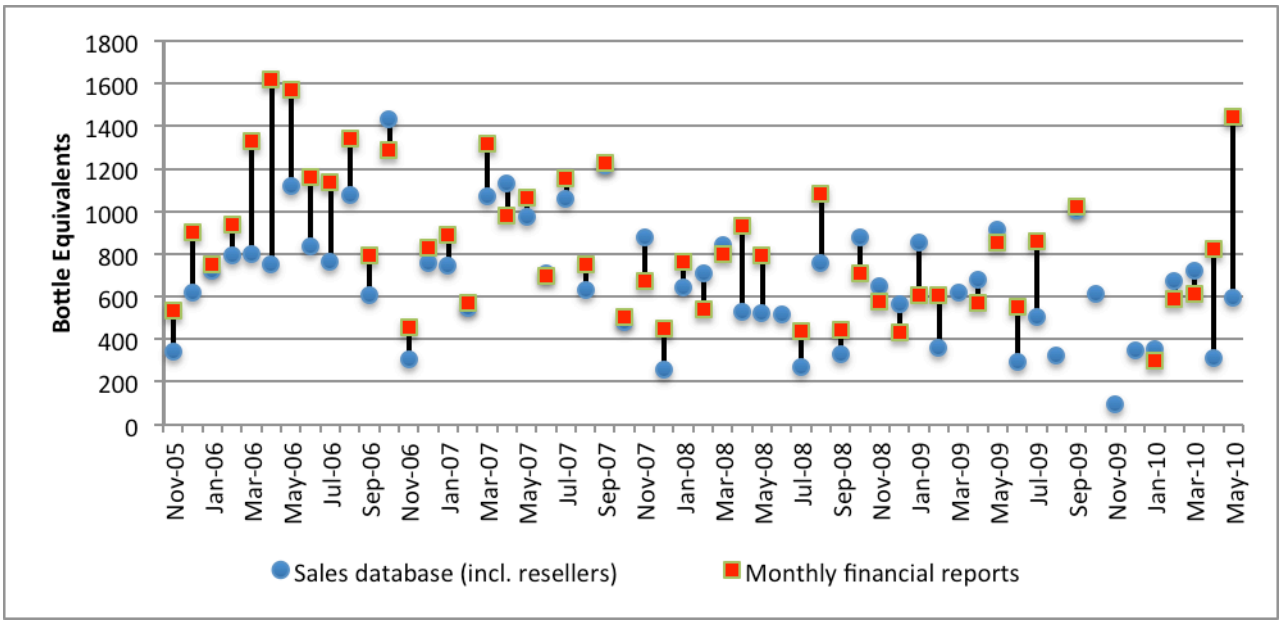
**Monthly financial reports missing for 5 months. Data from the 7 months with complete data was used to extrapolate for the missing months.

***Data from January-May 2010. Data from those months was used to extrapolate for the rest of the year.

In general, sales were underreported by an average of 16.5% per month, but ranged from negative 40.4% in January 2009 to 62.5% in April 2010. A positive average means that during an average month more bottles were reported sold to DSI than were entered into the individual household records. The year of 2010 shows the greatest percent of bottles sold that are unaccounted for in the individual records, but calculations were extrapolated from the five months of data that were collected that year.

Figure 12, below, demonstrates the monthly differences between the sales database and the financial reports. There are 6 months (all of which are in 2008 and 2009) that only have a single data point representing the sales database because the financial reports were not available. When the monthly financial report red square is plotted above the blue dot representing the sales database, more bottles of chlorine were sold than were recorded for individual households in the program books. As noted above, April 2010 had the largest percentage of sales missing from individual records (n=517.25), but this graph shows that other months, such as May 2010, had greater raw numbers of actual bottles unaccounted for (n=845.5).

Figure 12: Number of bottles from the sales database compared to the monthly financial records



Since monthly records were introduced as a way to report chlorine sales from JSWF to DSI in November 2005, a total of 3,997.5 total bottles in the monthly financial records were unaccounted for in the household records, which is equivalent to 21.7% of all program sales.

4.2.3 Resellers

Since the program covers such a large geographic area, it relies on resellers in various communities to make Gadyen Dlo available to program participants. Resellers began participating in the program in 2005 and have since been responsible for 33.6% of all chlorine sales, although they were responsible for about half of all sales in 2007, 2008 and 2009.

Resellers are present in 16 (8.6%) of the program's 182 communities (some communities have multiple resellers), 11 (68.8%) of which are less than one hour from Jolivert. Additionally, there are resellers in 15 (50.0%) of the 30 communities with the highest volume of chlorine sales. Of the remaining 15 communities without a reseller and high sales volume, 12 are within a one hour travel distance by motorcycle and/or foot from Jolivert and the other 3 communities are very densely populated and have a large number of program participants.

There have been 32 resellers affiliated with JSWF since 2005. There are two resellers that have been active for six years (recorded at least one high volume chlorine purchase every year since 2005) and an additional 13 resellers that have four to five years of activity; the remaining resellers have been active 3 years or less. The year with the highest number of active resellers (n=24) was 2007, which also recorded the second highest annual chlorine sales.

According to information from the program coordinator, only 10 (31.3%) of the 32 resellers have historically kept "good" records, which include the program participant's name, chlorine purchase date, and amount of chlorine purchased. At the time of research in May 2010, there were 16 active resellers and 6 (37.5%) of them were keeping "good" records, according to the project coordinator; the remaining 10 (62.5%) active resellers purchased chlorine from the program but did not report individual sales back to the program.

Table 8 displays the number of active resellers in a given year along with the sum of the number of bottle equivalents purchased by resellers. The number of bottles missing from the program records was calculated by the difference between the sum of total bottle equivalents in the household records and the monthly financial records each year. Monthly financial records were not kept prior to 2006.

Table 8: Reseller activity and number of missing bottles sold by year

Year	Number of resellers that made a purchase	Number of bottles (% total annual sales)	Mean number of bottles purchased	Number of bottles missing from records (% total)
2005	15	692 (8.6%)	21.6	No data
2006	21	2,884 (28.9%)	90.1	2,651(20.0%)
2007	24	4,773 (48.7%)	149.2	580 (5.6%)
2008	21	3,809 (52.8%)	119.0	328 (4.0%)
2009	18	3,302 (49.9%)	103.2	777 (9.0%)*

*monthly financial report data missing for 5 months of 2009; data from missing bottles from the 5 months of data were extrapolated to calculate the total number of missing bottles

Resellers were responsible for about 50% of all purchases in 2007, 2008 and 2009. It is hypothesized that the number of missing bottle equivalents is partially due to the lack of reporting individual chlorine sales by resellers. The years 2007, 2008 and 2009 each have at least two months during the given year

where more bottles were recorded in the household records than the program sales records, lowering the average of missing bottles throughout the year. All twelve months of 2006 have more bottles in the sales records than household records, which means that there was a lack of recording sales for reasons other than missing household sales from resellers.

During the survey, 180 (89.6%) of the 201 surveyed program participants reported where they purchased their most recent bottle of chlorine. While 98 (54.4%) of them reported purchasing chlorine from the JSWF program headquarters in Jolivert, 78 (43.3%) reported purchasing from resellers. Only 4 (2.2%) respondents purchased from a different source. Of the 78 participants that purchased from resellers, 46 (49.5%) of them lived one hour or more from Jolivert.

4.3 Survey

4.3.1 Survey Population Compared to Database

A total of 201 program participants were randomly selected for the household survey from a subset of participants accessible to the enumerators (see section 3.3 Household Survey for survey methods). The table below uses information from the database to compare the survey population to the program participants at large and restricted to the same geographical area from which the survey participants were selected (see section 3.3). Column A shows information from the database regarding the surveyed participants and is not data from the survey itself. A copy of the household survey can be found in Appendix A: Household Survey.

Table 9: Survey population compared to the restricted survey database and the restricted database compared to the entire database

	A Survey %,n	B p-value (A vs C)	C Database – restricted to survey area %, n	D p-value (C vs E)	E Database %, n
Total	100%, 201		100%, 4,034		100%, 4,609
Average Length of Time in Program (Months)	52.8 (48.7, 57.1)	0.740	54.6 (53.2, 56.1)	0.140	54.2
Ever Purchased Chlorine	38.2%, 76	0.112	43.7%, 1,763	**<0.001**	40.7%, 1,876
Multiple Chlorine Purchases	34.2%, 68	0.146	38.7%, 1,561	**<0.001**	36.5%, 1,682
Average # Bottles Purchased	6.90	0.499	11.09	0.106	10.41
Distance					
Jolivert area	6.5%, 13	**0.014***	6.4%, 259	**<0.001***	5.6%, 259
Bassin-Bleu area	18.9%, 38		25.9%, 1,045		22.7%, 1,045
< 1 hour	28.9%, 58		25.2%, 1,017		22.1%, 1,017
> 1 hour	45.8%, 92		42.4%, 1,712		47.4%, 2,184
Missing	0.0%, 0		0.0%, 1		2.3%, 104
Ever Received a Household Visit	48.7%, 97	**0.009**	40.4%, 1,630	**<0.001**	36.5%, 1,681
Mean # HH Visits	1.5 (1.13, 1.83)	0.832	1.7 (1.6, 1.8)	**<0.001**	1.5
Ever Received a Chlorine Residual Test	41.0%, 82	0.405	33.5%, 1,352	**<0.001**	30.1%, 1,385
Average % Positive	71.0%, 82	0.215	75.1%, 1,352, (73.3%, 77.0%)	**0.005**	75.5%

*Single p-value based on linearity of the distance variable.

In general, the survey population is very similar to the database population restricted to the survey area. There are non-significant p-values for differences in the average length of time in the program, having a recorded chlorine purchase and mean number of household visits. However, the percent of households

that ever received a household visit is significantly higher in the survey population (p=0.009); however, the percent of households that ever received a chlorine test is not significantly different between those surveyed and the database restricted to the survey area (p=0.405).

There are more significant differences observed between the database as a whole compared to the database restricted to the subset of communities from which the survey participants were randomly chosen. There were significantly fewer participants in the survey database at large who had ever purchased chlorine (p<0.001) or had multiple chlorine purchases (p<0.001). Additionally, significantly fewer participants in the survey database ever received a visit (p<0.001) or a chlorine residual test (p<0.001).

4.3.2 Concordance Between Survey and Program Database

Data obtained from the household survey can be a useful benchmark to examine the quality of the records that comprise the survey database.

In order to examine the quality of the sales records from the database, a question regarding the presence of chlorine in the household was used as a proxy for purchasing chlorine. A total of 125 (62.2%) of the 201 surveyed participants had no recorded purchases. Of those, 17 (13.6%) households refused to show the enumerator if they had a bottle of chlorine in the house or they did not have a bottle and 107 (86.4%) allowed the enumerator to see their bottle and measure the amount of chlorine present. Of the 107 participants who allowed the enumerator to see their bottle, 77 (72.0%) had chlorine at the time of the survey and were able to demonstrate it and the remaining 30 (28.0%) did not have any chlorine in the bottle.

Of the 77 households that had chlorine at the time of the survey and had no recorded purchases, 33 (42.9%) said they purchased from a reseller and 40 (52.0%) reported they purchased from the Jolivert clinic; one (1.3%) participant purchased from another source and three (3.9%) did not know where they purchased.

Based on self-reporting of chlorine purchases (not the presence of chlorine in the house), 188 (93.5%) households stated that they had made at least one chlorine purchase but database records only showed recorded purchases for 70 (37.2%) of them.

Additionally, part way through the survey implementation, the enumerators were asked to note whether the household's bottle for chlorine storage was transparent or opaque when measuring the quantity of chlorine in the bottle. The Gadyen Dlo program bottle is opaque and distributed from program headquarters in Jolivert. When considering the survey participants who had no recorded chlorine purchases but had chlorine present at the time of the visit (n=78), only 43 of them were surveyed after the question was added to the survey, of which 23 (53.5%) of the respondents had an opaque bottle, indicating that it was from the program.

When the surveyed program participants were asked if they had ever used Gadyen Dlo, 7 (3.5%) of them said that they had never used the product. Of the 184 participants who said they had used Gadyen Dlo at least once, only 67 (36.4%) of them had a recorded chlorine purchase. A total of 10 (5.0%) households did not answer the question.

Table 10 demonstrates the differences between self-reported purchases compared to the program records.

Table 10: Concordance between self-report during survey and program database

	Self Report		Sales Database		p
	Yes	No	Yes	No	
No. (%) Ever Purchased Gadyen Dlo (n=189)	187 (98.9)	2 (1.1)	70 (37.0)	119 (63.0)	<0.001

Of the 187 participants that reported a purchase of Gadyen Dlo branded chlorine (regardless of whether or not they had a recorded purchase in the program records), 96 (51.0%) of them reported making the purchase at the JSWF headquarters in Jolivert, 78 (41.5%) stated that they made the purchase from a reseller and 14 (7.4%) reported buying the chlorine from another source; one respondent did not know where they made the purchase (0.5%).

4.3.3 Distance

The average chlorine purchase size for a resident of Jolivert is 1.8 bottles per purchase. For these residents, the clinic is easily accessible and there are no resellers. In the Bassin-Bleu area, the average purchase size is slightly larger than in Jolivert at 4.2 bottles, but if the 379 outlier purchases in Bassin-Bleu that consisted of 16 or more bottles are dropped, the average purchase size is 2.6 bottles. Table 11 demonstrates the differences in average size of chlorine purchase by distance from Jolivert. Resellers were excluded from this analysis.

Table 11: Average quantity of chlorine purchase, among those with a recorded purchase, by location

	Average chlorine purchase size (bottles)
Jolivert clinic area (n=259)	1.8
Bassin-Bleu area (n=1,037)	4.2
< 1 hour from Jolivert (n=1,009)	7.1
> 1 hour from Jolivert (n=2,168)	11.9

Overall, 37.5% (n=534) of the 16 bottle equivalent (one gallon) purchases or greater were made by households that are more than one hour from Jolivert and an additional 244 (21.4%) were made by households within one hour but outside of the Jolivert and Bassin-Bleu area. The households more than one hour from Jolivert only made 507 (8.0%) single bottle purchases.

4.4 Valid Data Set

As noted above, there have been various inaccuracies and discrepancies noted in the program paper records. There are discrepancies between the sales database and the monthly financial records and it is known that the majority of resellers do not report household sales back to the program, but there were further inaccuracies noted when comparing the survey responses to program records.

Although Ritter was able to use the program database to make conclusions about the program in 2007, our hope to use the same records to continue his research is not possible since the records in 2010 were found to be incomplete. Due to the said discrepancies, the data set used for the remainder of the results will only include households in and around the towns of Jolivert and Bassin-Bleu (n=1,304). These towns are within 10 kilometers of Jolivert, have been involved with the program since 2003 or before and are believed to have complete records due to proximity to program headquarters and more frequent contact with the program. The communities that met these criterions will be used to examine the consistency of chlorine use.

4.5 Consistency of Use

4.5.1 Sales Records

A total of 64.0% (n=835) of the participants have at least one recorded chlorine purchase and 57.3% (n=747) have multiple purchases. However, when only considering households that made at least one purchase, 89.5% (n=747/835) of households had multiple purchases.

4.5.2 Household Visits

Overall, 61.5% (n=802) of the participants received at least one household visit, of which 12.6% (n=101) received a visit and had no recorded chlorine purchases. Of the households with at least one household visit, 89.3% (n=716) of them received multiple visits.

There have been a total of 4,876 household visits, during which free chlorine residual was checked during 3,536 (72.5%) of the visits; 92.6% (n=802) of the households with a visit received at least one chlorine residual test during a visit. Overall, 77.3% (n=2,733) of all tests were positive for free chlorine residual, defined as having at least 0.2 mg/L of chlorine present in the water, which is noted by a pink color change by the technicians. The percentage of positive chlorine residual tests among this subgroup in the valid data set is slightly lower than the overall average of positive chlorine residual tests (77.5%).

4.5.2.1 Timing of Household Visits

Of all household visits, 41.2% (n=2,900/7,307) were conducted the month of or after a household made a chlorine purchase.

When looking at the frequency that a household made a chlorine purchase after they received a household visit, the households that had a recorded chlorine purchase in the three months prior to the visit were excluded (based on the assumption that a consistent purchaser would make one purchase per quarter; explained below in section 4.5.3). When looking at the program as a whole, 19.2%

(n=866/4,518) of visits resulted in a chlorine purchase the month of or after a visit. When considering only the households around Jolivert and Bassin-Bleu in the valid data set, 20.5% (n=585/2,849) of visits resulted in a chlorine purchase.

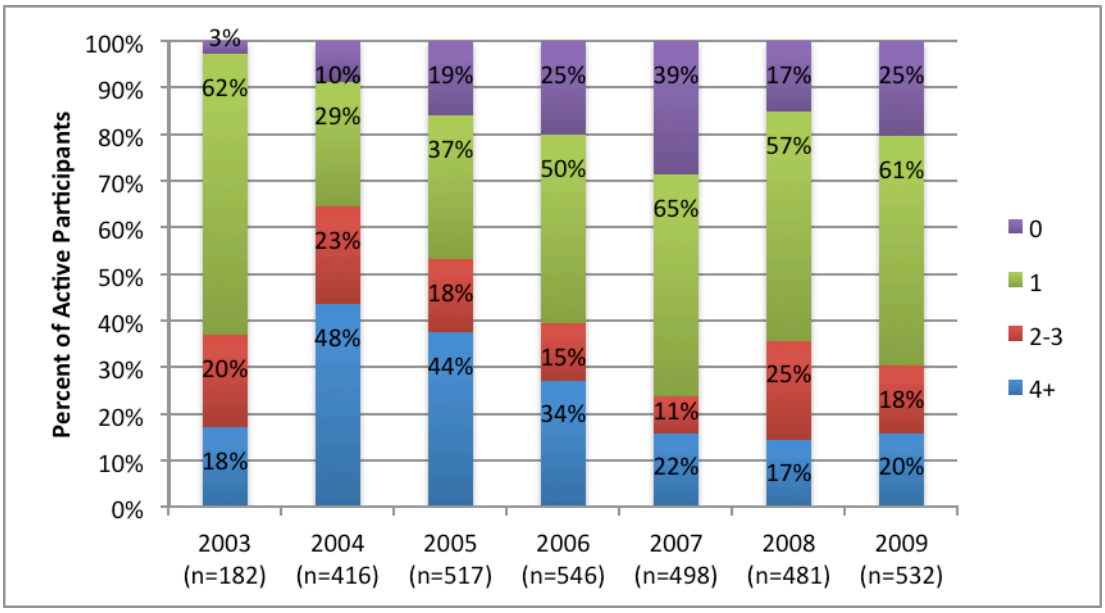
4.5.3 Consistency of Use

To examine the number of participants that make consistent purchases and the trends of consistent use over time, analysis was performed for all years with 12 months of data (2002 and 2010 were excluded because they are incomplete years of data).

The CDC estimates that the average Haitian family uses a minimum of 20 liters of water for drinking and cooking per day (Lantagne, 2008) which is equivalent to 5.3 gallons of water; one cap, or 6 milliliter treatment, of Gadyen Dlo disinfects 5 gallons of water. Each bottle of chlorine is 250 milliliters, which would be sufficient to treat drinking water for 42 days. Treating water every other day is considered to be consistent use, which would require the purchase of 4 bottles of chlorine per year.

Figure 13, below, shows the percent of participants who made a purchase in the given year stratified by the quantity of chlorine purchases; "4+" bottles purchased in the calendar year is considered to be the proxy for consistent use. Participants were not included in the analysis if they did not have a program start date and were dropped from the analysis if they had no recorded purchase in the stated year or the year before under the assumption that they left the program. Resellers (n=8) were excluded from the analysis.

Figure 13: Consistency of chlorine purchases over time



Although the number of consistent purchasers reached a high of 48% (n=198) in 2004, the average percent of consistent users in a given year is 29.7%. When considering long-term consistent use, the overall percentage of participants purchasing at least four bottles of chlorine annually decreased every year from 2004 to 2008.

There have been calls for research to examine consistency of use in water chlorination programs that have been in existence longer than five years in order determine if interest wanes and people stop participating or people actually form habits and continue using the product. The year 2007 was the fifth full calendar year of the JSWF program and it showed that 22% of the participants made consistent purchases. Similar numbers are seen in 2008 and 2009 (years six and seven of the program). The average percent of participants making consistent purchases from 2007 to 2009 is 20.7%.

Although only about one-fifth of program participants make enough purchases to treat all of their drinking and cooking water, an average of 80.3% of program participants make at least one recorded chlorine purchase per year.

When considering all of the program participants in the Bassin-Bleu and Jolivert areas who have records in the program database in 2009 (n=1,296), 214 (16.5%) households made a purchase every year since they entered the program (resellers excluded). A total of 515 (39.7%) households have no recorded chlorine purchases. Of those with no recorded purchases, 399 (77.5%) also did not have a recorded start date, meaning that only 116 (8.9%) participants that have a record of entering the program did not make a purchase.

The 214 households that had a recorded purchase every year since entering the program have a significantly higher average of positive chlorine residual tests at 83.1% compared to those who did not have a recorded purchase every year since entering the program at 74.0% positive ($p<0.001$). The two groups had a similar number of chlorine residual tests ($p=0.512$).

Households with any chlorine purchase have a significantly higher percentage of positive chlorine residual tests than households without a recorded chlorine purchase ($p=0.010$).

4.6 Survey Results

The survey provides another method to not only look at the consistency of chlorine use, but also to gauge the participant's understanding of why they are using the chlorine and if they know how to properly use it, which reflects on the training provided to them. Section 4.3 Survey discussed the validity of the survey in comparison to the program as a whole. A copy of the survey can be found in Appendix 1.

4.6.1 Survey demographics

The survey included questions on the participants' demographics, but as discussed previously, the program sales and visits records show only the participants' name and location with no other demographic markers. This lack of information in the program records is the reason why there was no

demographic comparison between the survey and database in section 4.3.1 Survey Population Compared to Database.

A total of 201 program households were surveyed along with 425 matched control households from 72 communities. Overall, 444 (70.9%) of the respondents were female and the average age of the respondent was 40 years old, ranging from 13 to 90 years old.

The average length of schooling was 9 years and 72.2% (n=452) of respondents had attended school. The level of education between program participants and controls was similar (p=0.729).

Respondents traveled a mean of 28.3 minutes to collect water (ranging from 0 to 220 minutes) and did so an average of two times per day. Although the time needed to collect water was somewhat similar between program participants and controls (p=0.065), controls collected water more frequently (p=0.005).

4.6.2 Treatment methods

Respondents were asked to volunteer which water treatment methods they had heard about, all options are demonstrated below in Table 12. Significantly more program participants volunteered Gadyen Dlo (p<0.001) but 40.1% (n=170) of controls had also heard of it. Significantly more controls identified citrus (p=0.015) and used citrus (p=0.012) as a water treatment method and nearly half of all controls volunteered a water treatment method not listed below.

Table 12: HWTS methods survey participants had heard of (multiple answers possible)

Treatment Method	Program Participants (n=201)	Controls (n=424)	All (n=525)	p-value
Gadyen Dlo (number, (%))	194 (96.5)	170 (40.1)	364 (58.2)	<0.001*
Boiling (number, (%))	54 (26.9)	138 (32.6)	192 (30.7)	0.150
Aquatabs (number, (%))	44 (21.9)	101 (23.8)	145 (23.2)	0.593
Dlo Lavi (number, (%))	7 (3.5)	17 (4.0)	24 (3.8)	0.749
Racket (number, (%))	7 (3.5)	19 (4.5)	26 (4.2)	0.559
Citrus (number, (%))	32 (15.9)	104 (24.5)	136 (21.8)	0.015*
Filter (number, (%))	3 (1.5)	6 (1.4)	9 (1.4)	0.939
Pur (number, (%))	3 (1.5)	2 (0.5)	5 (0.8)	0.181
Commercial bleach (number, (%))	44 (21.9)	189 (44.6)	233 (44.4)	<0.001*
Other (number, (%))	2 (1.0)	15 (3.5)	17 (3.2)	0.068

*Denotes significant p-value

As expected, significantly more participants were able to identify Gadyen Dlo has a treatment method ($p<0.001$), but 40.1% (n=170) of controls had also heard of the product. Significantly more controls heard of using citrus as a treatment method ($p=0.015$).

Overall, 44.6% (n=189) of controls compared to 21.9% (n=44) of participants stated that they have heard of commercial bleach (Clorox or Jif) as a water treatment method ($p>0.001$).

Table 13 outlines the HWTS options that survey participants reported using at some point, either at the time of the survey or in the past. A total of 95% (n=191) of program participants and 39.5% (n=168) of controls reported using Gadyen Dlo.

Boiling water as an additional treatment method was reported by 25.9% (n=52) of program participants and 22.9% (n=46) report using other treatment methods.

Table 13: HWTS options that survey participants have used (multiple answers possible)

	Program Participants	Controls	All	p-value
Gadyen Dlo (number, (%))	**191 (95.0)**	**168 (39.5)**	**359 (57.4)**	**<0.001***
Boiling (number, (%))	52 (25.9)	132 (31.1)	184 (29.4)	0.183
Aquatabs (number, (%))	43 (21.4)	98 (23.1)	141 (22.5)	0.641
Dlo Lavi (number, (%))	7 (3.5)	16 (3.4)	23 (3.7)	0.861
Racket (number, (%))	7 (3.5)	18 (4.2)	25 (4.0)	0.653
Citrus (number, (%))	31 (15.4)	103 (24.2)	134 (21.4)	0.012*
Filter (number, (%))	3 (1.5)	6 (1.4)	9 (1.4)	0.937
Pur (number, (%))	2 (1.0)	2 (0.5)	4 (0.6)	0.442
Commercial bleach (number, (%))	44 (21.9)	186 (43.8)	230 (36.8)	<0.001*
Other (number, (%))	46 (22.9)	201 (47.3)	247 (39.5)	<0.001*

*Denotes significant p-value

Significantly more controls than participants reported using commercial bleach to treat their water. However, among those controls, 101 (54.3%) said that they rarely used commercial bleach to treat their water and 30 (16%) stated that they never used it as a treatment method.

4.6.3 Gadyen Dlo Use

A total of 45.2% (n=65) of program participants reported using Gadyen Dlo every day, 26.4% (n=53) said that they used it in the past week, 15.0% (n=30) in the past month and 8.0% (n=16) said that they were unsure how often they used Gadyen Dlo. Only one household admitted to only using Gadyen Dlo one time and no household responded that they had never used the product. Use of Gadyen Dlo was reported by 10.37% (n=44) of controls, of which 5.0% (n=21) reported using it daily.

However, a similar question was asked near the beginning of the survey regarding the forms of household water treatment the respondent had heard of and if they had ever used that form of treatment and the responses were significantly different ($p<0.001$). Table 14 demonstrates the

differences in answers based on the survey questions. The responses "in the last month" and "don't know" were only available in the question that specifically asked about Gadyen Dlo use.

Table 14: Frequency of Gadyen Dlo use responses in different survey questions among program participants

	Reported use of Gadyen Dlo after voluntarily reporting having heard of it (n=194)	Reported use of Gadyen Dlo when explicitly asked (n=192)
	n(%)	n (%)
Daily	65 (33.5)	92 (45.8)
One time per week	71 (37.2)	53 (26.4)
In the last month	*	30 (14.9)
Rarely or only one time	51 (36.6)	1 (0.5)
Never	4 (2.1)	0 (0.0)
Don't know	*	16 (8.0)
No response	3 (1.5)	9 (4.5)

*response was not an option in that survey question

Despite such a high number of reported Gadyen Dlo users, when asked directly about the last time they treated their water only 66.1% (n=80) of participants who reported using Gadyen Dlo daily were able to demonstrate the presence of chlorine to the enumerator at the time of the survey. Of those who reported using it in the past week, 29.75% (n=36) were able to demonstrate chlorine.

Table 15, below, outlines reported knowledge and use of Gadyen Dlo among participants and controls.

Table 15: Gadyen Dlo reported and actual use among participants and controls

Variable	Participants	Controls	p
No. (%) who reported having heard of Gadyen Dlo when asked to list all known water treatment methods (volunteered knowledge)	194/201 (96.5)	170/424 (40.1)	<0.001
No. (%) who reported using Gadyen Dlo after voluntarily reporting they had heard of it	191/201 (95.0)	168/424 (39.6)	<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 drinking water with any treatment method	**153/195 (78.5)**	129/404 (31.9)	<0.001
No. (%) who had a positive chlorine residual in their current drinking water (> or = to 0.2 mg/L)	**108/176 (61.4)**	25/258 (9.7)	<0.001

The table above shows that 45.7% of participants reported treating their drinking water with Gadyen Dlo in the past 24 hours but 61.4% of households had a positive chlorine residual test. As shown in Table 13, many participants and controls had heard of commercial bleach as a way of treating their drinking water. A total of 78.5% of participants reported treating their drinking water with any treatment method, which explains why more households had positive chlorine residuals than reported using Gadyen Dlo in the past 24 hours.

Table 16 below shows the reported reasons that participants do not use Gadyen Dlo.

Table 16: Reported reasons for not using Gadyen Dlo (multiple answers possible)

Reason for not using Gadyen Dlo (n=201)	**n (%)**
Ran out	99 (49.3)
Cannot afford it	82 (40.8)
Water is already safe	6 (3.0)
Gadyen Dlo has a bad smell	18 (9.0)
Gadyen Dlo has a bad taste	2 (1.0)
Other reason	28 (13.9)

4.6.4 Program participant training

Technicians are responsible for training program participants regarding the importance of water treatment and the correct dosing of Gadyen Dlo. Table 14 demonstrates that Gadyen Dlo participants understand that pathogens in the water are what makes it unsafe to drink ($p<0.001$) and that clean appearing water is not synonymous with disinfected water ($p=0.029$). Additionally, 94.0% (n=189) of participants reported using Gadyen Dlo because it disinfects water. Only one participant stated use of Gadyen Dlo because they were instructed to do so.

Table 17: Percent of respondents who perceive their water as safe to drink (multiple answers possible)

	Program Participants	Controls	p-value
Believe their water is safe to drink (number, (%))			
Why they believe their water is safe to drink:	n=199	n=424	
Water looks clean/is clear (number, (%))	48 (24.1)	130 (30.7)	0.092
Water without germs/bacteria (number, (%))	**181 (90.1)**	**281 (66.3)**	**<0.001***
Water from tap (number, (%))	13 (6.5)	28 (6.6)	0.973
Water warm (number, (%))	0 (0.0)	2 (0.5)	0.332
Other	11 (5.5)	57 (13.4)	0.003*

*Denotes significant p-value

Having a friend (p=0.800) or family member (p=0.100) who uses GD did not impact if a household purchased Gadyen Dlo.

A total of 168 participants responded to a question regarding whether or not they received training; only 3 (1.79%) participants responded that they had never received training.

Table 18 demonstrates the knowledge of how to use Gadyen Dlo and reported use. Although only 165 (82.1%) participants that reported receiving training on Gadyen Dlo, 195 (97.0%) participants were able to correctly tell the enumerator how much chlorine to add to a five liter bucket. Only 148 (73.6%) participants were able to identify the need to wait 30 minutes after treating the water before consumption.

Full knowledge of both the volume of chlorine and the 30 minute wait time before consumption was not higher among participants who reported receiving training (p=0.379). Significantly more program participants (67.7%) than controls (2.8%) had a safe water storage container present at the time of the survey (p<0.001).

Table 18: Gadyen Dlo knowledge and use among program participants

	Program Participants (number, (%))			
	Yes	No	Didn't know	Missing
Reported ever purchasing Gadyen Dlo	182 (90.5)	2 (0.3)	6 (3.0)	11 (25.5)
Reported ever using Gadyen Dlo	184 (91.5)	7 (3.5)	7 (3.5)	3 (1.5)
Reported using Gadyen Dlo today	92 (45.8)	109 (54.2)	16 (8.0)	9 (4.5)
Received training	165 (82.1)	3 (1.5)	0 (0)	33 (16.4)
Correct knowledge of 5L volume	191 (95.0)	1 (0.5)	7 (3.5)	2 (1.0)
Correct knowledge of 30 minute wait	148 (73.6)	19 (9.5)	32 (16.0)	2 (1.0)
Safe water storage observed	196 (97.5)	1 (0.5)	2 (1.0)	2 (1.0)

The participants that reported more frequent water treatment were more likely to demonstrate proper knowledge of how to use Gadyen Dlo than the participants who treated their water less frequently ($p<0.001$).

4.6.5 Survey Results by Geography

The restriction of the data from the household records for analysis was done on geographical location based on the finding that those records were more accurate than the records for the communities located further from program headquarters. The same restriction was applied to survey results to see if there were any differences based on geography. Of the chlorine residual tests performed at the home of participants outside of the Jolivert and Bassin Bleu area during the survey, 62.8% (n=81) were positive compared with 57.5% (n=27) positive tests within that area ($p=0.519$). The surveyed participants within the Jolivert/Bassin-Bleu area had an average of 2.7 household visits during their time in the program compared to the participants outside that area that had an average of 0.42 visits.

Table 19: Gadyen Dlo reported and actual use among surveyed participants, restricted by geography

Variable	Participants from valid data set (n=51)	Outside of Jolivert/Bassin-Bleu area (n=150)	p
No. (%) who reported having heard of Gadyen Dlo when asked to list all known water treatment methods (volunteered knowledge)	48/51 (94.1)	146/150 (97.3)	0.279
No. (%) who reported using Gadyen Dlo after voluntarily reporting they had heard of it	45/46 (97.8)	142/145 (97.9)	0.965
Daily Use	15/46 (32.6)	50/145 (34.5)	
Once per week	18/46 (39.1)	53/145 (36.6)	
Rarely	2/46 (4.4)	13/145 (9.0)	
Once	10/46 (21.7)	26/145 (17.9)	
Never	1/46 (2.2)	3/145 (2.1)	
No. (%) who reported having heard of Gadyen Dlo when explicitly asked	49/51 (96.1)	143/149 (96.0)	0.974
No. (%) who reported ever using Gadyen Dlo	49/50 (98.0)	135/141 (95.7)	0.466
No. (%) who reported now using Gadyen Dlo	38/48 (79.2)	111/139 (79.9)	0.918
No. (%) who reported treating their drinking water with Gadyen Dlo in the past 24 hours	30/49 (61.2)	62/143 (43.4)	0.087
No. (%) who had a positive chlorine residual in their current drinking water (> or = 0.2 mg/L of chlorine)	27/47 (57.5)	81/129 (62.8)	0.519

Table 20: Gadyen Dlo knowledge and use among surveyed program participants, restricted by geography

	Participants from valid data set (n=51)	Participants outside of Jolivert/Bassin-Bleu area	p
No. (%) that reported ever purchasing Gadyen Dlo	51/51 (100.0)	146/150 (97.3)	0.239
No. (%) that reported ever using Gadyen Dlo	49/50 (98.0)	135/141 (95.7)	0.466
No. (%) that reported using Gadyen Dlo today	30/49 (61.2)	62/143 (43.4)	0.049*
No. (%) that reported receiving training	40/51 (78.4)	125/150 (83.3)	0.430
No. (%) that reported receiving sufficient training	31/32 (96.9)	83/97 (85.6)	0.084
No. (%) with correct knowledge of 5L volume	47/51 (92.2)	137/150 (91.3)	0.855
No. (%) with correct knowledge of 30 minute wait	44/51 (86.3)	104/150 (69.3)	0.018*
No. (%) with observed safe water storage	50/50 (100.0)	146/147 (99.3)	0.559

*denotes significant p-value

Overall, the participants had similar results even though they differed geographically in proximity to the program headquarters. More participants within the valid data set treated their water within the 24 hours prior to the survey, but 26.0% (n=39) treated their water within the seven days prior to the survey compared to 27.5% (n=14) of those in the valid data set. Significantly more participants within the valid data set had correct knowledge of the need to wait 30 minutes to used treated water after adding the chlorine solution, however, there was no difference in knowledge regarding the amount of chlorine needed to treat five liters of water (participants were asked about both clear and turbid water treatment).

4.6.6 Health Impact Results from Survey

Survey participants had significantly less diarrhea than controls, demonstrated in the chart below (Harshfield, 2011). Additionally, participants had 26% reduced odds (OR=0.74, 95% CI 0.52-1.05) of diarrhea among the general population and a 55% reduced odds (OR=0.45, 95% CI 0.23-0.86) among children less than five years of age.

Table 21: Diarrhea prevalence in randomized case-control survey

	Participants	Controls	p-value
Overall diarrhea prevalence	14%	21%	<0.001
Children <5 diarrhea prevalence	31%	52%	0.001

For more results regarding the health impact results from the survey, see Harshfield 2011.

4.7 Limitations

Although the data were gathered from the records kept by the program, there are imperfections that must be considered when analyzing and interpreting the data.

When the program started in 2002, the resellers kept a log of which families purchased chlorine and the date and quantity of the purchase. They were also responsible for selling buckets to new participants and recording those bucket numbers and family names. When the resellers returned to the program headquarters in Jolivert, they relayed this information to the program coordinator who would update the program records to reflect the purchases that were made. However, starting gradually in 2006 and becoming more prominent in 2007, resellers no longer kept consistent records of their sales. Since there is no way to determine which program participants purchased chlorine from a reseller, the individual sales records for participants who purchased from resellers from 2007 to 2010 are not accurate, but the overall amount of chlorine sales are unaffected.

Additionally, individual sales may be falsely low due to clerical error. When the sales records were entered into Excel, information was also entered regarding overall monthly sales. The monthly sales records are equivalent to the raw number of bottle equivalents sold during a given month and are derived by summing the daily sales. Entries from the daily sales book are recorded into the individual

household records in the community books and they are also combined at the end of a given month to report total sales to the program. When comparing the monthly financial reports with the summed individual sales by month from the sales database, there are discrepancies, resulting in an average of 21.7% of bottles from monthly financial reports that are unaccounted for in the sales database each month. In other words, there were more bottles sold each month than were recorded in the community books, which means that the analysis on individual sales by be underestimated.

When determining a program participant's consistency of use category, "regular", "sometimes", or "non-user", some participants may have been miscategorized based on missing data due to clerical error or the absence of reports from resellers. This miscategorization would also affect the analysis correlating purchase history with the results of household visits. Some households, especially those who joined after 2007 and purchase chlorine from resellers, may appear as if they have never purchased chlorine. If these individuals have positive chlorine tests, final analysis could be misleading by showing that consistent chlorine sales do not affect consistent chlorine use based on residual tests. Conversely, if they have negative chlorine tests, it would support the conclusion that people who do not purchase chlorine do not treat their water. All of the communities with resellers have received household visits.

Additionally, when analysis was performed on the consistency of chlorine use by program households, data from the unannounced household visits were used. The analysis uses all of the data available, but this data is only available for communities that are within a distance from Jolivert that allows the technicians to travel, perform visits, and return in one day. Communities that were too difficult to get to by walking or motor transport had no chlorine residual tests recorded. Out of the 4,609 program participants, only 1,484 households (32.18%) had received a chlorine test. Therefore, conclusions

regarding the consistency of use over the lifetime of the program are really based on a sample of participants from the communities that are closest to program headquarters. It would then also be concluded that these program participants that live in communities near to the headquarters also have more contact with the program, which may influence, and thus increase, their consistency of use, which may falsely elevate the estimated consistency of chlorine use among all program participants.

Chapter 5: Discussion

5.1 Quality of Program Records

The Jolivert Safe Water for Families program has impressive records at the household level spanning the eight years the program has been operating. A remarkable 47,861.5 bottle equivalents of chlorine were sold since 2002 and the program technicians performed an incredible 4,926 chlorine residual tests.

The goal of this thesis was to use the wealth of data in the program records to examine the consistency of use in this long-term water chlorination program. However, despite an impressive set of records, it became apparent that not all of the records were of the same quality. When comparing household records with overall sales records and survey responses, there were inconsistencies in the records for households located distant to Jolivert.

Since the last time research was done on the program records in 2007, the program expanded both in number of participants as well as number of communities, over half of which are located more than one hour from Jolivert. It would have been financially and logistically unmanageable for all of the families that wanted to buy chlorine to travel to the clinic to make purchases; money that could be spent on Gadyen Dlo would have been spend on transportation instead. Therefore, resellers started playing a larger role in making Gadyen Dlo accessible to households that live outside the Jolivert area.

The use of resellers was an answer to the logistical problem of distribution and until 2007, it was a way for the program to increase sales outside of Jolivert and still be able to maintain accurate records. Resellers acted as pseudo-staff members as they were asked to keep records of Gadyen Dlo sales while at the same time being able to make an income off of each sale.

However, during 2007, after Michael Ritter conducted his research, the majority of resellers stopped reporting sales to the program. So, although Gadyen Dlo was accessible to program participants, many households made purchases without the program having any written record of the purchase. According

to the program staff, resellers no longer wanted to keep records because they felt it was too time consuming and not worth their effort when they were able to make sales, and therefore a profit, regardless of whether or not they kept records for JSWF. This had a large impact on the quality of the records since the resellers made up a total of about 50% of program sales each year since 2007. As the program continued to expand geographically and resellers comprised a higher percentage of total sales, fewer individual sales were recorded in the program records.

In addition to having incomplete sales records for participants living further from the program, those participants also received fewer overall household visits and had a lower rate of visits based on the number of months enrolled in the program as the program employed only two technicians to provide visits and produce chlorine despite increases in the number of participants.

5.2 Data Quality

The major goal of this thesis was to address the question of whether or not program participants in long-term water chlorination programs achieve consistent chlorine use over time. As discussed, program records declined in quality after 2007 as the program expanded and consequently relied heavily on resellers to distribute Gadyen Dlo. According to the project coordinator, the resellers felt that reporting individual sales to the program required too much uncompensated work and time and therefore many resellers discontinued reporting sales, although they still vend the product.

As shown in section 4.3.2 Concordance Between Survey and Program Database, 78 surveyed participant households had chlorine at the time of the survey and did not have a recorded purchase. 34 (43.6%) of those participants said that they purchased chlorine from a reseller. Since the majority of resellers stopped reporting individual sales the program, it is impossible to know which households purchased from a reseller, which negatively impacts the consistency of use calculations, especially for the populations living further from Jolivert who are more likely to purchase from resellers ($p=0.001$).

However, of those 78 households that had chlorine and no recorded purchase, 48 (61.5%) of them said that they purchased chlorine form the Jolivert clinic. Figure 12 outlined a large deficit of unaccounted bottles sold in the program records equivalent to 21.7% of all program sales since 2005.

Although it is possible that participants were falsely reporting purchases or visits, it is not likely since so many of the participants had chlorine present at the time of the survey without recorded purchases. Additionally, there was no incentive to a household to falsely report a household visit.

In separate analysis of the average number of bottles sold per purchase, there was a positive correlation between the distance of a household from the clinic and the number of bottles purchased in a single day, shown in Table 11. Since the records for the households living outside of the Jolivert and Bassin-Bleu areas are not as complete as the records for the households near the headquarters, the larger volume purchases negatively influence the consistency of use calculations. When performing the consistency of purchase analysis, a "consistent" purchaser was defined as purchasing at least four bottles in a calendar year. However, since the average purchase is larger in communities more than one hour from Jolivert, a single purchase could theoretically provide an average household with enough chlorine for nearly three years, but that household would only be considered a consistent user the year of purchase. Additionally, it is not possible to know if a person is purchasing chlorine for their household alone or if they are also purchasing for their neighbors since there is increased travel associated for Gadyen Dlo access for this population.

5.2.1 Analysis Restriction

Based on inaccurate purchase records, different purchase patterns and fewer household visits for households located more than one hour from Jolivert, much of the analysis was restricted to the program area within one hour from the program headquarters because they presumably had the most accurate records.

The households near Jolivert (n=1,304) were used to assess consistent use of chlorine in the home which provide insight into the effectiveness of a program like JSWF when kept at a manageable size.

Although this restriction resulting in a smaller sample size than originally planned was not ideal, analysis on the consistency of chlorine purchase and use could be performed on a subgroup group of program participants which have more contact with the program based on the higher rate of purchases and higher rate of households visits (rates calculated from total months enrolled in the program).

5.3 Consistent Use

5.3.1 Chlorine Purchases

Over the life of the program, an average of 29.7% of the participants in a given year purchased enough chlorine chlorine to treat all of their estimated drinking water; an average of 80.3% of participants were active with one with one or more purchases in a given year (see

Figure 13: Consistency of chlorine purchases over time).

There have been calls for research to examine consistency of use in water chlorination programs that have been in existence longer than five years in order determine if interest wanes and people stop participating or if people develop habits and continue using the product long-term. 2007 was the fifth full calendar year of the JSWF program and it showed that 22% of the participants made consistent purchases, as seen in Figure 13, defined as four or more bottles in a calendar year. Similar numbers are seen in 2008 and 2009 (years six and seven of the program). The average percent of participants making consistent purchases from 2007 to 2009 is 20.7%.

Since much of the literature suggests that people lose interest in water chlorination programs after five years, when only looking at the sixth and seventh years of the program, an average 79% of households made at least one purchase and an average of 18.5% of households made enough purchases to treat all of their estimated drinking water in those years. So, although the average percentage of households making purchases declined after five years, there were still a large number of households actively participating in the program.

Although not all participants purchased enough chlorine to treat all of their drinking water since their entry into the program, the majority of active participants were at least intermittently purchasing chlorine. There may be multiple reasons why people do not purchase enough chlorine to treat all of their water.

One theory is that people do not understand how to dose the chlorine and are using less liquid than needed to effectively treat their water. However, this theory does not hold true based on the household survey that showed that 95.0% (n=191) of program participants surveyed had correct knowledge on how to dose Gadyen Dlo chlorine.

Another theory is that people cannot afford to purchase the product, which was supported in the survey in that 40.8% (n=82) of the cases reported the cost as a reason for not purchasing Gadyen Dlo. JSWF started selling half-bottles of chlorine in 2009 to address this issue. In fact, several of the survey enumerators stated that many of the participants surveyed reported purchasing small sachets of Clorox brand chlorine based on convenience and smaller cost per purchase. There was no data collected on the prevalence of people purchasing Clorox, but the program is aware that cost may be a burden to many families.

There may be critics that argue that since there is a financial burden on some households, the program is not sustainable. However, half of the 82 households that responded that not they could not afford

Gadyen Dlo as a reason for not treating their water had made at least one purchase in the past. Many households may have some financial burdens that occur, but the majority of participants did not feel that the cost of the product made Gadyen Dlo inaccessible; programs like JSWF make chlorine accessible and affordable to many households.

This subset of households showed that although the level of participation varied between households and within one household over time, overall interest in the program does not decline after five years like much of the published research has suggested.

5.3.2 Household Visits

The program technicians were able to complete an incredible number of household visits (n=7,037) that resulted in 4,926 chlorine residual tests, of which 77.5% (n=3,891) were positive over the life of the program. Household visits and chlorine residual tests provide a different perspective than purchase history by which to examine consistent use of chlorine to treat household water.

The household visits performed by the technicians were not randomized, but they were unannounced. The overall percent of positive chlorine residual tests is impressive; however, the household survey recorded 61.4% positive chlorine residual tests in randomized visits resulting in a 16.1% bias in the program records (see table 15). There are a couple of factors that were identified that could falsely elevate the percentage of positive tests from program records:

1. It was speculated that the data on household visits could be inaccurate if technicians were primarily visiting households that they knew had a recent purchase. However, even if technicians were visiting households that recently purchased Gadyen Dlo, the pattern seen in the records was that visits were done on a community level. That is to say, if they visited a household with a purchase in community "A", many of the other participating households in community "A" also received a household visit. So essentially, even if the technicians were

targeting households who recently made a purchase, many other households located near the targeted household also received a visit.

2. It is possible that even when visits were done on a community level, technicians were still able to target households within a community that they knew were consistent users as 55.8% (n=3,924) of chlorine residual tests were performed in households that had three or more visits recorded. If these households were targeted, it could be that these visits served as reinforcement to the households using chlorine. However, only 10.3% (n=501) of household visits resulted in a participant making a purchase the month of or after a visit, showing that household visits may not influence purchases as much as originally thought.

Either way, if the technicians were indeed visiting households they knew to be chlorine users, it would have falsely elevated the overall percentage of positive tests when in fact the overall percentage of positive tests in households that received more than three visits (77.2%) was lower than the overall percentage of household visits (77.5%).

Despite any discrepancy between the survey and the household records of positive chlorine residual tests, the numbers are impressive. The survey was able to span a larger geographical area than the program technicians are able to on their own; only 85 (42.3%) of surveyed participants had ever received a household visit prior to the survey and of those 85 households, 32 of them did not receive a chlorine residual test during their survey. As the majority of survey participants never received a visit or a chlorine test before the survey, it is impressive that 61.4% of the chlorine residual tests were positive during random, unannounced visits. This result shows that even without any reinforcement from the program, there are many participants who chlorinate their water.

5.4 Program Size and Accessibility

The JSWF program experienced rapid growth from 2007 through 2010, nearly doubling the number of active participants. The program added a large number of communities as well as large cities like Port-de-Paix, the capital of the Northwest department. Although the program was able to establish resellers in some of these larger communities, it was unable to track purchases, make household visits or provide education on chlorine use to the participants. Additionally, during the survey it was found that 25.9% (n=52) of the participants reported boiling their water in addition to chlorinating it and 22.9% (n=46) reported other additional treatment methods, which raises the question of the accessibility of Gadyen Dlo with program expansion (see Table 16). Situations like this raise the question of whether or not a program like JSWF can expand and remain effective.

JSWF started in the communities surrounding Jolivert, presumably targeting the families that accessed the Jolivert clinic. The initial goal was to provide a household visit to each participating household every six months to monitor their chlorine use and provide ongoing education. An additional goal was to record purchases, but this was mainly for research purposes such as this thesis, program funding and as a good business practice.

As the program expanded, the number of staff did not, making it impossible for the technicians to both make enough chlorine for the growing number of participants and provide the target number of visits and education. The data analyzed for consistency of use in this thesis looked only at the population of participants near Jolivert that were in the catchment area that the technicians were able to manage. Although very few households received the target number of visits, households near Jolivert received significantly more visits and a higher rate of visits per year in the program than people located further from Jolivert.

Over 50% of the program population lived greater than one hour from Jolivert, yet in 2009 only 10.4% of that population received a household visit. Although prior to 2009 the percentage of positive chlorine residual tests in this population was similar to the communities closer to Jolivert, it plummeted in 2009 to 51.2% positive (41 tests) among households greater than one hour from Jolivert compared to 90.1% positive (232 tests) in the Jolivert area. Without hiring more program staff, it is neither feasible nor plausible for the technicians to maintain contact with participants living more than one hour from Jolivert to provide encouragement and education. However, this is a larger problem than just a lack of household visits; participants living in more distant communities do not have the same access to Gadyen Dlo as households living closer to Jolivert.

Although the technicians may not be in contact with many of the participants living outside of the Jolivert area, it is possible that word-of-mouth between participants or other organizations, such as churches, may be taking the initial role of the technicians by providing education to participants regarding Gadyen Dlo and the benefits of treating drinking water. During the survey, it was found that although only 82.1% (n=165) of people reported that they had received training about Gadyen Dlo, 90.1% (n=181) of those surveyed understood that using chlorine kills pathogens in the water and 95.0% (n=191) of survey participants had correct knowledge of dosing. Additionally, 97.5% acknowledged the need for safe water storage.

Overall, it is promising to see that more people are receiving education on Gadyen Dlo than have been officially trained in its proper use and speaks to the possibility that a program like JSWF can be sustainable as it expands.

Since households located distant to the Jolivert clinic received fewer household visits and the program has virtually no purchase records for that population, the question then remains, does the program remain effective as it expands?

Survey analysis showed that participants are knowledgeable on proper use of Gadyen Dlo and more participants report purchasing Gadyen Dlo than have program records that indicate a purchase. Additionally, during the survey, more than half of the participants had never received a household visit, yet the overall percentage of positive residual tests was 63.0% indicating that households are still using chlorine in more remote areas despite not receiving household visits.

There are minimal records documenting Gadyen Dlo purchases in communities far from Jolivert, yet resellers presented to Jolivert from as far away Port-de-Paix to purchase large amounts of chlorine and new safe water systems to be sold in their areas, which would indicate a demand for the products.

The JSWF program now needs to decide, as the program expands, if it is necessary to maintain records on the household level. There is evidence that households continue to use and treat their water without the program providing visits, which is really a tribute to behavior change. The change seen in the more remote communities may be on a smaller, household level among early adopters rather than on a community level, as seen in Jolivert, but it is progress nonetheless.

Although there is a lack of definitive evidence supporting the consistent use of chlorine among households in communities distant to Jolivert, there are promising signs that show that some households have adopted water chlorination as a treatment method and use a SWS in their home without marketing and monitoring from JSWF.

5.5 Value of Household Visits

As discussed previously, the goal for the technicians was to provide a household visit to each participant every six months. Over time that goal became unachievable, especially in years there was high chlorine demand like in 2007. As shown in Table 5, there were very few chlorine residual tests performed in 2007, but that year had the highest sales.

Figure 11 demonstrates that there is very little difference seen in the percent of positive chlorine residual among households with a single visit versus ten or more visits, contradicting the theory that additional household visits have real-world significant impact on chlorine use.

Additionally, when looking at the percentage of household visits that resulted in a chlorine purchase as a way to examine the impact a household visit has as motivation for behavior change, only 19.2% of visits may have impacted the households decision to purchase chlorine overall (see 4.5.2.1 Timing of Household Visits). Knowing that there may be an issue with access to Gadyen Dlo for the participants in communities further from headquarters and that they have more incomplete records, it was necessary to see if the trend was the same in the restricted database area of communities in and around Jolivert and Bassin-Bleu. A similar result was found there with 20.5% of visits resulting in chlorine purchases.

Although there is data showing that 41.2% of all household visits were conducted the month of or after a household made a chlorine purchase and that 19.2% of all visits resulted in a chlorine purchase, the causality cannot be determined.

Furthermore, there is evidence of behavior change among households who have no recorded household visits. Analysis of the survey showed that although only 48.7% of the surveyed participants had ever received a household visit and only 40.1% had ever received a chlorine residual test (reference Table 9), 61.4% of all the chlorine residual tests during the survey were positive (reference Table 15).

5.6 Culture of Chlorination in Haiti

Originally, the goal of the thesis was to look at the consistency of Gadyen Dlo branded chlorine use over time. However, it makes sense to shift the definition of success to one that looks at behavior change and health knowledge among program participants as the nature of the program continues to change while it expands.

Despite the background culture of chlorination in Haiti, significantly more program participants reported treating their drinking water ($p<0.001$) and had chlorine residual at a level sufficient to treat their drinking water at the time of the survey ($p<0.001$). During the survey it was discovered that many of the program participants and controls alike use commercial bleach as a method of water treatment. Regardless of the type of chlorine being used, participants are more likely to have treated water than people who do not participate in the program. With that being said, if participants are using commercial bleach, it really speaks to a higher level of behavior change than if they were solely relying of Gadyen Dlo chlorine. It is known that Gadyen Dlo is becoming less accessible to participants as the program expands geographically, so the use of a commercial product means that participants are finding an accessible way to acquire a product to treat their water, even if Gadyen Dlo is not accessible.

5.7 Health Impact and Behavior Change

The data collected from the program records was not only useful to examine the take-up of the JSWF program over time, but was also used in conjunction with the randomized household survey. It was found that participants had a significantly lower prevalence of diarrhea than controls, demonstrating a positive impact on the health of participants. Although many controls use commercial bleach to chlorinate their water (refer to table 13), significantly more participants were able to identify that chlorinating water makes it safe to consume because it cleared harmful bacteria (refer to table 17). Although no definitive conclusion can be made about the reasons that drive people in the program to consistently treat their water, with Gadyen Dlo or otherwise, knowing why they treat their water could be an important factor driving them to make the monetary investment of treating their water.

It is known that there is a culture of water chlorination that was in Haiti before the JSWF program started. The survey was able to shed some light on the number of program participants that purchase commercial bleach in place of or in addition to Gadyen Dlo (see table 14).

The most common reason that participants do not use Gadyen Dlo is that they ran out of the product, followed by cost (see Table 16). However, over 30% of the participants that said that cost was an issue had positive chlorine residual results at the time of the survey, which may indicate that they were using a commercial chlorine product. For more information on the health impact of the JSWF program, refer to the thesis written by Eric Harshfield (2011).

Chapter 6: Recommendations

Despite a wealth of data spanning eight consecutive years, it is not feasible to make conclusions regarding the long-term consistency of use throughout the Jolivert Safe Water for Families Program. The goal of this thesis was to answer a question that has been raised in many papers regarding the long-term feasibility of water chlorination program. Based on data inconsistencies and uncertain causalities, no definitive conclusion could be made regarding the long-term effectiveness of the JSWF program. The data gathered, however, provided some insight into the relative effectiveness of the program among a subset of the program population and an optimistic viewpoint that behavior change can be seen among many of the participants based on consistent purchases and positive chlorine residual tests. The data gathered for this thesis was also incorporated into a journal article regarding the health impact of the JSWF program.

Although no definitive conclusions regarding consistency of use were made, the research for this thesis was able to examine JSWF program records and program operations. Through the in-depth review of the program, themes for program recommendations emerged to help make the program more successful in the future.

6.1 Resellers and Program Staff

It was apparent that records at the household level were more incomplete for the households located further from Jolivert. The participants that rely on resellers for access to Gadyen Dlo often have no purchase records and due to the distance they live from Jolivert, likely never received a visit.

Resellers were initially approached about selling Gadyen Dlo because they already had an established store or were community leaders in some capacity, which also inevitably meant that they were busy and had other commitments that may have prohibited them from keeping records for the program.

The program may benefit from restructuring the model for resellers. Initially it made sense to use community leaders and store owners to make the product available in order to utilize social marketing and to make the product available in marketplaces where people were already shopping. The Gadyen Dlo product is now more recognized and in the household survey 40.1% (n=170) of controls had heard of the product identified by the brand name. Although it is important to sell the chlorine in an easily accessible location, it no longer seems necessary to continue to solely use community leaders and storeowners to vend Gadyen Dlo.

For example, one of the resellers in Port-de-Paix is a young woman who is an artist. She painted her Gadyen Dlo bucket on the side of her house and according to her, many community members asked where they could get a bucket like the one she painted. After enough of her neighbors showed interest in the product, she decided to become a reseller so she could sell the buckets and chlorine out of her home. She is one of the few resellers that provide purchase records to the program.

The program would benefit from recruiting people like this young lady who are interested in selling the product for the program as a means for employment. Currently, the program is allowing people who already have a source of income to make additional money off the sale of Gadyen Dlo, but there are

many other people who are in need of employment and may be more willing to provide information to the program as a condition of employment.

It is also proposed that these new resellers are also in charge of performing household visits to the families that purchase Gadyen Dlo from them. Since it was found that household visits have very little impact on purchases, the visits could be performed on an as-needed basis. The incentive for resellers to visit households would be to encourage families to purchase Gadyen Dlo and continue to educate them on the impact water chlorination could have on the health of their household. Additionally, a preliminary educational visit should be considered to make sure that the family understands the system and the reasons for water chlorination. By hiring resellers dedicated to their position, there would be no need to hire more paid staff and the program technicians would be able to concentrate on producing the chlorine and providing household visits near Jolivert.

6.2 Regional Headquarters

Since the program continues to expand geographically, many participants and resellers have to travel an hour or more to access Gadyen Dlo. Based on information from the survey, it is known that Gadyen Dlo is already too expensive for some participants and many people use Clorox chlorine instead of Gadyen Dlo, which is likely due to a smaller cost per purchase or increased availability. When communities are mapped out geographically, it appears that the new communities are primarily located north of Jolivert. As more than 50% of participants now live greater than one hour from Jolivert, it may be time to consider starting a regional headquarters in a major city north of Jolivert.

Starting a new chlorine production location would be costly for the program. A new location would have to be built, purchased or rented, in addition to purchasing the equipment to make chlorine. Further research needs to be done to assess the cost-benefit of adding an additional headquarters.

An alternative would be for the program to take orders from resellers and send a truck once per month to a central location with those orders. That way, resellers would not need to spend so much money and time to get to Jolivert to restock Gadyen Dlo and buckets. By making sure there is no break in the supply of Gadyen Dlo in these communities, JSWF is helping to ensure availability of the product.

During the household survey, respondents were not asked to state how much they paid for chlorine if they purchased from resellers. It would be advisable to research the price for which resellers are selling Gadyen Dlo based on their distance from Jolivert. Although the program advises the resellers to sell a bottle of chlorine for twice the price it is sold for in Jolivert so resellers can make a profit, there is no enforcement of the price resellers charge. As they have to travel further, it is possible that the resellers are setting higher prices to compensate for increased transportation costs. This is an area for future research, which may help with the decision of starting a regional headquarters.

6.3 Conclusion

Overall, the program has done a good job advertising their product and continuing to expand the program. Demand for Gadyen Dlo products has expanded far beyond the original program area. This program provides a product that makes water treatment and storage accessible for the average family, which can have health benefits for the entire household. The JSWF has expanded to a point where they can no longer continue the goal of providing household visits to all participants or record all sales. Despite these shortcomings, it is promising to see that there is such a large population that is interested in household water treatment and that the program continues to grow and expand after 8 years.

Although not all households treat their drinking water consistently, the majority of active participants within the Jolivert area are making at least one purchase a year. According to the survey, many households are accessing other forms of chlorine, such as Clorox, which may cost less or be more accessible. Although the JSWF sustains itself off the sale of its own products, the fact that people are

using other chlorine speaks to behavior change achieved in these program participants that do not have access to Gadyen Dlo.

Success can be measured on different levels; initially JSWF measured its success based on positive chlorine residual tests during unannounced visits and regular Gadyen Dlo purchases by program participants from the clinic or from resellers. As the program expanded, the original measures of success became more difficult and program records were not able to maintain their original quality, which made the initial measurements of success difficult to measure. It is necessary to consider other markers of success when looking at the long-term sustainability of a program such as JSWF that is constantly growing.

The survey was able to demonstrate other measures of success. For example, 1) it became known that over half of the survey participants had never received a household visit prior to the survey and still 61.4% of the residual tests were positive, 2) there were no significant differences between the number of households with positive chlorine residuals based on distance demonstrating that households with less contact with the program are chlorinating their water, 3) despite not having records of Gadyen Dlo purchases many survey participants had chlorine at the household level at the time of the survey, 4) participants more distant from Jolivert received fewer household visits and less direct training from technicians but still the majority of survey respondents had correct knowledge of how to use Gadyen Dlo, 5) many households admitted to purchasing and using commercial bleach due to limited access to Gadyen Dlo which indicates behavior change, and 6) survey participants had significantly less diarrhea than their counterparts.

The culture of chlorination in Haiti was discussed earlier, but there were still significantly more participants with chlorine in their water at the time of the survey, which is yet another measure of success.

Although the measures of success for the program have changed as the program has evolved, the JSWF has reached thousands of households in northwestern Haiti and made them aware of the importance of home water chlorination to prevent water transmissible diseases and has shown a proven reduction in diarrheal disease among participants as well as a high percent of chlorine users after eight years of program operation.

References

Arnold, B. F., & Colford, J. M., Jr. (2007). Treating water with chlorine at point-of-use to improve water quality and reduce child diarrhea in developing countries: a systematic review and meta-analysis. *Am J Trop Med Hyg, 76*(2), 354-364.

Brin, G. (2003). Evaluation of the Safe Water System in Jolivert, Haiti by Baceriological Testing and Public Health Survey. Retrieved November, 18 2010, from http://www.jolivert.org/research/brin.pdf.

Bryce, J., C. Boschi-Pinto, et al. (2005). "WHO estimates of the causes of death in children." Lancet 365(9465):1147-1152.

Clasen, T., Bartram, J., Colford, J., Luby, S., Quick, R., & Sobsey, M. (2009). Comment on "Household water treatment in poor populations: is there enough evidence for scaling up now?". *Environ Sci Technol, 43*(14), 5542-5544; author reply 5545-5546.

CDC. (2005). Preventing Diarrheal Disease in Developing Countries: The Jolivert Safe Water for Families Project in Rural Haiti. Retrieved from http://www.cdc.gov

CDC. (2006). Preventing Diarrheal Disease in Developing Countries: The Safe Water System Program. Retrieved from http://www.cdc.gov

CDC. (2008a). Chlorine Residual Testing Fact Sheet. Retrieved from http://www.cdc.gov

CDC. (2008b). Preventing Diarrheal Disease in Developing Countries: Proven Household Water Treatment Options. Retrieved from http://www.cdc.gov

Eisenberg, J. N., Scott, J. C., & Porco, T. (2007). Integrating disease control strategies: balancing water sanitation and hygiene interventions to reduce diarrheal disease burden. *Am J Public Health, 97*(5), 846-852.

Kirchhoff, L., McClelland, K., Pinho, M., Araujo, J., De Sousa, M., & Guerrant, R. (1985). Feasibility and efficacy of in-home water chlorination in rural North- eastern Brazil. *Epidemiology and Infection, 94*(02), 173-180.

Fewtrell, L., Kaufmann, R. B., Kay, D., Enanoria, W., Haller, L., & Colford, J. M., Jr. (2005). Water, sanitation, and hygiene interventions to reduce diarrhoea in less developed countries: a systematic review and meta-analysis. *Lancet Infect Dis, 5*(1), 42-52.

Global Issues in Water, Sanitation, and Health: Workshop Summary. (2009). Institute of Medicine (US) Forum on Microbial Threats, National Academy of Sciences. Retrieved from http://www.ncbi.nlm.nih.gov/bookshelf/br.fcgi?book=nap12658&part=ch1

Hernandez, O. (2007). *Measuring Behavioral Outcomes When Promoting Household Water Treatment and Storage*. Paper presented at the USAID/Hygiene Improvement Project. Retrieved from http://www.hip.watsan.net/page/1964

Kasper, A. (2007). Safe Water System (SWS) - Effect of Chlorination on Inactivating Selected Pathogens: Centers for Disease Control and Prevention.

Lantagne, D. (2008). Sodium hypochlorite dosage for household and emergency water treatment. *Journal of the American Water Works Association, 100*(8), 106-119.

Lantagne, D., Melerhofer, R., Allgood, G., McGuigan, K. G., & Quick, R. (2009). Comment on "Point of Use Household Drinking Water Filtration: A Practical, Effective Solution for Providing Sustained Access to Safe Drinking Water in the Developing World". *Environmental Science and Technology, 43*(3).

Luby, S. P., Agboatwalla, M., Hoekstra, R. M., Rahbar, M. H., Billhimer, W., & Keswick, B. H. (2004). Delayed effectiveness of home-based interventions in reducing childhood diarrhea, Karachi, Pakistan. *Am J Trop Med Hyg, 71*(4), 420-427.

Mintz, E., Bartram, J., Lochery, P., & Wegelin, M. (2001). Not just a drop in the bucket: expanding access to point-of-use water treatment systems. *Am J Public Health, 91*(10), 1565-1570.

MSPP. (2007). Haïti: Enquête Mortalité, Morbidité et Utilisation des Services 2005- 2006. Pétion-Ville, Haïti; Calverton, Maryland, USA: Ministére de la Santé Publique et de la Population (MSPP), Macro International, Inc.

Olembo, L., Kaona, F., Tuba, M., & Burnham, G. (2004). *Safe Water Systems: An Evaluation of the Zambia Clorin Program*: Johns Hopkins Bloomberg School of Public Health.

Parker, A. A., Stephenson, R., Riley, P. L., Ombeki, S., Komolleh, C., Sibley, L., et al. (2006). Sustained high levels of stored drinking water treatment and retention of hand-washing knowledge in rural Kenyan households following a clinic-based intervention. *Epidemiology and Infection, 134*(5), 1029-1036.

Pickering, A. J., Davis, J., Walters, S. P., Horak, H. M., Keymer, D. P., Mushi, D., et al. (2010). Hands, water, and health: fecal contamination in Tanzanian communities with improved, non-networked water supplies. *Environ Sci Technol, 44*(9), 3267-3272.

Population Totale. (2009). Population de 18 Ans et Plus Menages et Densites Estimes en 2009.

http://www.ihsi.ht/pdf/projection/POPTOTAL&MENAGDENS_ESTIM2009.pdf

Quick, R. E., Venczel, L. V., Mintz, E. D., Soleto, L., Aparicio, J., Gironaz, M., et al. (1999). Diarrhoea prevention in Bolivia through point-of-use water treatment and safe storage: a promising new strategy. *Epidemiology and Infection, 122*(1), 83-90.

Ritter, M. (2007). Determinants of Adoption of Household Water Treatment in Haiti Jolivert Safe Water for Families (JSWF) Program. Atlanta, GA, USA: Emory University.

Ritter, M., Lantagne, D. (2011) Determinants of household water treatment adoption using sodium hypochlorite in rural Haiti. Submitted.

Schmidt, W. P. and S. Cairncross (2009). "Household water treatment in poor populations: is there enough evidence for scaling up now?" Environ Sci Technol **43**(4): 986-992.

Sobsey, M. D., Stauber, C. E., Casanova, L. M., Brown, J. M., & Elliott, M. A. (2008). Point of use household drinking water filtration: A practical, effective solution for providing sustained access to safe drinking water in the developing world. *Environ Sci Technol, 42*(12), 4261-4267.

Thevos, A. K., Kaona, F. A., Siajunza, M. T., & Quick, R. E. (2000). Adoption of safe water behaviors in Zambia: comparing educational and motivational approaches. *Educ Health (Abingdon), 13*(3), 366-376.

UNICEF. (2008). *WHO Progress on Drinking Water and Sanitation: Special Focus on Sanitation*: Fund Joint Monitoring Programme for Water Supply and Sanitation (JMP): Geneva.

UNICEF. (2006). At a glance: Haiti. Retrieved from http://www.unicef.org/infobycountry/haiti.html

WHO, & UNICEF. (2010). WHO/UNICEF joint monitoring report 2010: Progress on Sanitation and Drinking Water. Retrieved from http://whqlibdoc.who.int/publications/2010/9789241563956_eng.pdf

WHO. (2006). Global Health Observatory, Haiti: Data and Statistics. Retrieved from http://www.who.int/gho/countries/hti/data/en/index.html

Wright, J., Gundry, S., & Conroy, R. (2004). Household drinking water in developing countries: a systematic review of microbiological contamination between source and point-of-use. *Trop Med Int Health, 9*(1), 106-117.

Appendix A: 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.

____ _____
Person Obtaining Consent

HH Number

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

Q41.

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

Emory University
1599 Clifton Road, 5th Floor - Atlanta, Georgia 30322
Tel: 404.712.0720 - Fax: 404.727.1358 - Email: irb@emory.edu - Web: http://www.irb.emory.edu/