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Adoption of the SAWYER Water Filter in Peru

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by

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DEDICATION

This work is dedicated to my Papi. Thanks for encouraging me to go on this adventure and thanks for watching over me from up above.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

In Peru, lack of water, sanitation, and hygiene (WASH) results in 6,600 deaths per year that represents approximately 3.9% of total deaths. Three thousand and nine hundred of these deaths were due to diarrheal diseases (Prüss-Üstün et al., 2008). Systematic reviews suggest that interventions to improve microbial quality of drinking water are successful in reducing diarrheal diseases (Fewtrell et al., 2005; Clasen et al., 2007; Fry et al., 2013). Interventions for household water treatment and safe storage to ensure safe drinking water reduce diarrhea by 31-52% (WHO/UNICEF, 2013).

The SAWYER PointONE filter, a portable and adaptable membrane filtration device as small as the hand, is one point-of-use (POU) technology option for populations that rely on unsafe water from an improved source, or for areas that still rely on unimproved water sources for drinking and cooking. The filter functions strictly through mechanical exclusion accomplished by a hollow fiber membrane. The filters are certified for 0.1 μm as the largest pore size; therefore preventing diarrhea-causing bacteria such as *E. coli*, cholera, and typhoid to pass through the membrane.

This research focuses on SAWYER water filter users who use a filter purchased through a sales agent in Independencia, Ica, Peru. Fifteen households in 9 communities and a total of 39 individuals were surveyed with the overall goal of better understanding the adoption of the SAWYER water filter as a POU water treatment technology in relation to three themes of: 1) household socio-economic factors 2) water, sanitation and hygiene (WASH) related characteristic and behaviors of users, and 3) Health Belief Model factors.

The results showed SAWYER water filter users to have higher socio-economic status on average. All households had a high Progress out of Poverty Index® (PPI®) score. The heads of households, both

male and female, were found to be more educated than the national average. Female heads of house were more educated than the male heads of house. There was a significant difference in the education levels of the female heads of house as compared to the national levels (p =0.006), with the female heads of house in the study having superior university degrees at three times the national percentage. The heads of house were also married at a higher percentage than the national average.

SAWYER water filter users also have greater access to media than the regional average. All homes were equipped with at least one TV with cable. Results showed a significant difference in households having a computer within the home as compared to the regional percentage (p < 0 .001) and also in having Internet in the home as compared to the regional percentage (p < 0.001).

Most houses (13/15) have running water all the time and all have a sink, shower, and toilet. Indoor connection and sewage type were not found to be statistically different from national average. Most people (67%) reported to always use soap and several participants mentioned liquid handwashing soap. Users reported handwashing after going to the bathroom (64.1%) more than before eating (38.5%) or cooking (46%).

The Health Belief Model survey revealed that SAWYER water filter users perceive diarrhea as more severe for children, even though they do consider themselves susceptible. Clear benefits of adopting the filter include saving money, improving water quality, and saving time, but the barriers to filter adoption were unclear. Most users had contact with another person who demonstrated or recommended the filter prior to adopting the filter, highlighting the importance of interpersonal contact for promoting filter use. Turbidity during rainy season was also found to be an important cue to action.

CHAPTER 1: INTRODUCTION

The Joint Monitoring Program (JMP) for Water and Sanitation reported that in 2010, the 2015 Millennium Development Goal target to halve the proportion of people without sustainable access to safe drinking water had been met. Global coverage for improved water reached 89% in 2012 (WHO/UNICEF, 2014), but this target does not address the safety or reliability of the water being provided. Furthermore, the JMP estimates that 1.8 billion people globally still have fecal contamination in their drinking water source.

As seen in Table 1-1, the JMP reported Peru to have an overall improved water coverage of 87% in 2012, with up to 91% of the urban population having access to an improved water source. In rural areas of Peru where coverage drops, 28% of habitants rely on unimproved water sources for drinking. The reported improved water coverage in Peru may however be an overestimate. For example, in many urban areas, continuous service is scarce and a lack of proper maintenance of the distribution network leads to burst pipes or blockages (Giugale et al., 2006). Sustainability of a water supply has been characterized as a system that provides "equitable access amongst all members of a population to continual service at acceptable levels providing sufficient benefits, and reasonable and continual contributions and collaboration from service, consumers, and external participants" (Schweitzer and Mihelcic, 2012). In the District of Independencia, Peru where part of this study takes place, the water services do not meet this definition: frequent water shortages and lapses in service lead many people to rely on a secondary water source.

Table 1-1. Access to water sources in Peru.

Access to water source for Peru (as a percentage of population)					
			1990	2000	2012
Urban	**Improved**	**total improved**	88	90	91
		Piped on premises	73	80	87
		other improved	15	10	4
	Unimproved	other unimproved	11	9	8
		surface water	1	1	1
Rural	**Improved**	**total improved**	44	56	72
		Piped on premises	11	34	63
		other improved	33	22	9
	Unimproved	other unimproved	29	22	12
		surface water	27	22	16
TOTAL	**Improved**	**total improved**	74	81	87
		Piped on premises	54	67	82
		other improved	20	14	5
	Unimproved	other unimproved	17	12	9
		surface water	9	7	4

Adapted from World Health Organization/United Nations Children's Fund (2014). Progress on sanitation and drinking-water – 2014.

An "improved drinking water source" can be defined as a source that "by the nature of its construction and when properly used, adequately protects the source from outside contamination, particularly faecal matter" (JMP, 2015). This includes piped water into the home or yard, a public tap, a tubewell or borehole, a protected dug well, a protected spring, or rainwater (JMP, 2015). An improved water source should theoretically provide safe drinking water, but does not necessarily always do so. Water can be contaminated anywhere between source and user: throughout the distribution system, during collection, and at storage (Trevett et al., 2004; Rufener et al., 2010; Semenza et al., 1998; Levy et al., 2008). "Safe drinking water" can be defined as water with microbial, chemical, and physical characteristics that meet World Health Organization guidelines or national standards for drinking water quality (WHO, 1997).

The lack of access to potable water and sanitation is a threat to public health and childhood nutrition and exacerbates conditions for those living in poverty. Globally, the diarrheal disease burden in low- and middle- income countries amounts to an estimated 502,000 deaths annually due to unsafe water, 280,000 deaths due to inadequate sanitation, and 297,000 deaths preventable with better hand hygiene (Prüss-Ustün et al., 2014). In Peru, lack of water, sanitation, and hygiene (WASH) results in 6,600 deaths per year, representing approximately 3.9% of total deaths. Three thousand and nine hundred of these deaths were due to diarrheal diseases (Prüss-Üstün et al., 2008).

Systematic reviews suggest that interventions to improve microbial quality of drinking water are successful in reducing diarrheal diseases (Fewtrell et al., 2005; Clasen et al., 2007; Fry et al., 2013). One estimate from 12 studies found water treatment at the household level, also known as point-of use (POU), to be more effective in reducing rates of diarrheal disease than interventions at the water source (Clasen et al., 2007). Furthermore, interventions for household water treatment and safe storage to ensure safe drinking water reduce diarrhea by 31-52% (WHO/UNICEF, 2013). While many POU technologies exist (reviewed in Mihelcic et al. 2009) including chlorination, solar disinfection, coagulant/disinfectant tablets, biosand filters, other types of filtration, ceramic or otherwise, or any method that is used at the point of consumption to improve water quality (Schweitzer et al., 2013) (Clasen et al., 2007), boiling currently has the most sustained, large scale use (Sobsey et al., 2008).

POU water treatment can empower people without access to safe water by allowing them to treat water within their homes. POU also has the advantage of allowing users to select a particular technology according to their needs and preferences. For example, a study in Keyna showed that out of three POU products, a dilute hypochlorite solution, a flocculant-disinfectant powder, and a ceramic filter, the filter ranked as the preferred product in 400 households (Albert et al., 2010). Different POU technologies and implementation strategies have been shown to have varying, but significant diarrheal disease reduction rates. Studies show a range of reduction in diarrheal disease rates after a POU

intervention, from 19% (for PuR tablets) to as high as 72% (through the use of ceramic candle filters) (Sobsey et al., 2008).

The SAWYER PointONE filter, a portable and adaptable membrane filtration device as small as the hand, is one POU technology for populations that rely on unsafe water from an improved source, or for areas that still rely on unimproved water sources for drinking and cooking. In 2014, an entrepreneur from the United States started the company Durabio in Peru. Marketing itself as a "distributor of a simple, life-enhancing technology," the company began to offer SAWYER water filters to the Peruvian market that year. Durabio intends to rebrand a product that is used in the United States primarily for outdoor recreation into a domestic product to be used for improving the quality of life of many Peruvians. The purchase and use of the SAWYER water filter for POU water treatment has however been slow in the company's first year, with most of Durabio's revenue coming from commercial sales to businesses that cater to tourists. For a company that aims to improve the quality of life of Peru's neediest populations, it is important to understand the motivations of those who choose to invest in a product like the SAWYER filters, and what holds back those who do not.

1.1 Research Motivation

The author served as a Peace Corps Volunteer as part of the Master's International Program (Mihelcic, 2010; Mihelcic et al., 2006; Manser et al., 2015) from 2013-2014 in the District of Independencia, Pisco, Ica (see Figure 2-3a). After her Peace Corps service, she remained in Peru working for Durabio, the distributors of the SAWYER water filter. Her work at Durabio included translation, design of promotional strategies and marketing materials, and sales. Observing the lack of interest in water quality by the municipality in Independencia while living there, she returned to make the product available and work remotely for Durabio, traveling when necessary. Recruiting a local couple known as salesmen in the community to promote and sell the product, the team made a few sales.

Although the thesis author was employed by Durabio when this study was carried out, she did not receive any supervision or compensation for the study from Durabio. The study was completed as a thesis requirement for the author's Master's International Program and the study was not in any way related to her work with Durabio. The author did however adopt the SAWYER water filter as a POU water treatment filter for her personal use while living in Peru. The author's personal and potentially subjective experiences as a filter user certainly contributed to motivation for this study. She herself was hesitant to use the filter at first and only began to use it to avoid purchasing bottled water and creating solid waste. She witnessed the same general distrust of the new product and a lack of interest in purchasing the filters amongst members of the community. The thesis author was curious why some were much more willing to adopt a new technology while others remained resistant to a product that had potential to greatly enhance their quality of life. This curiosity developed into a research project with the aim of filling the knowledge gap about a product only recently available in Peru along with trying to determine what motivates the technology's early adopters. Accordingly, this study focuses on the early adopters of the SAWYER PointONE water filter and their beliefs, their personal and household characteristics as related to WASH, and their motivations. Readers should thus note that the author's experience as a SAWYER PointONE water filter user and a community member in Independencia may influence the interpretation of data in this study.

1.2 Goals and Hypotheses

The overall goal of this research is to better understand the adoption of the SAWYER water filter as a POU water treatment technology in relation to three themes depicted in Figure 1-1: 1) household socio-economic factors 2) water, sanitation and hygiene (WASH) related characteristic and behaviors of users, and 3) Health Belief Model factors. The themes, subsequent hypothesis related to each theme, and factors chosen to quantify them, were developed through a detailed literature review and the author's experience in Peru as a community member, a SAWYER water filter user, and a researcher.

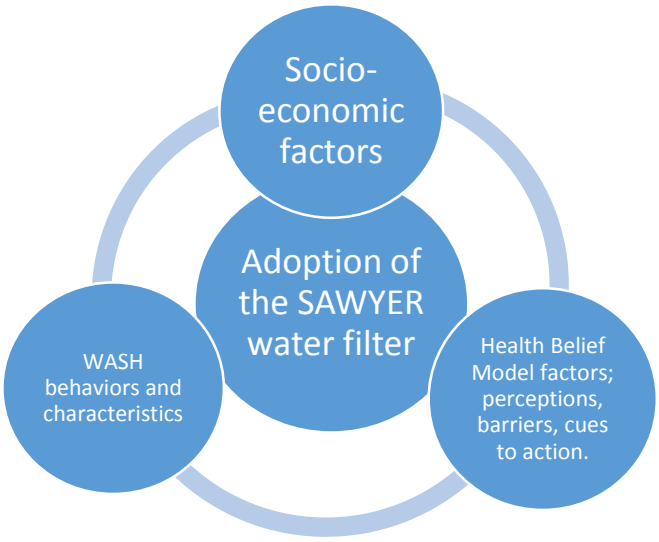

Figure 1-1. Framework for the themes related to the adoption of the SAWYER water filters.

Hypothesis 1 – Houses that have adopted the SAWYER filter will have a higher overall socio-economic status.

This hypothesis was tested by collecting data on the following socio-economic factors of households that had adopted the filter that include: PPI SCORE, married/cohabitating/single, rural/urban, media access, place of birth, family size, and level of education as detailed in the following tasks

1) Calculate the Progress out of Poverty (PPI) index for each household.
    a. Assess where each household falls on a national scale in Peru.
    b. Determine if PPI scores are associated with filter adoption.
2) Determine the level of education of the heads of households and observe if there is an association with adoption of the SAWYER filter.
3) Determine whether marital status can be associated to the adoption of a SAWYER water filter.
4) Determine if household residence in an urban or rural area is associated with filter adoption.

5) Determine if an association exists between access to Internet/television and filter adoption.

Hypothesis 2 – Houses that have reliable water access, sanitation facilities, practice handwashing, and have proper water storage and water treatment practices are more likely to adopt a SAWYER water filter.

This hypothesis was tested by collecting data on the following information: water access, water treatment and storage, sanitation facility, and hand washing practices as detailed in the following tasks

1) Determine if access to running water is associated with filter adoption.
2) Determine if more water storage through the use of underground storage or roof tanks correlates to the adoption of the SAWYER water filter.
3) Assess the correlation between the presence of an improved sanitation facility and filter adoption.
4) Assess the correlation between proper handwashing habits and adoption of filter through the following factors:
    a. Handwashing facility,
    b. Use of soap,
    c. Knowledge of critical handwashing moments.

Hypothesis 3 – Perceived susceptibility to diarrheal diseases and high self-efficacy as outlined in the Health Belief Model will have the highest correlation to the adoption of SAWYER water filters.

This hypothesis was tested by collecting data on perceived seriousness, perceived susceptibility, perceived benefits, perceived barriers, cues to action, and self-efficacy (Hayden, 2009) through the use of a survey.

1) Quantify the following Health Belief Model factors:
    a. Perceived seriousness of water related illnesses/diarrheal disease,

b. Perceived susceptibility to water related illnesses/diarrheal diseases,

c. Perceived benefits of adopting the SAWYER water filter,

d. Perceived barriers to adopting a SAWYER water filter,

e. Cues to action that may lead to the adoption of a SAWYER water filter,

f. Self-efficacy of users that have adopted the filter.

2) Identify which factors under the expanded Health Belief Model can be associated to the adoption of a SAWYER water filter.

a. Assess the statistical associations of perceived seriousness and filter adoption.

b. Assess the statistical associations of perceived susceptibility and filter adoption.

c. Assess the statistical associations of perceived benefits and filter adoption.

d. Assess the statistical associations of perceived barriers and filter adoption.

e. Assess the statistical associations of cues to action and filter adoption.

f. Assess the statistical associations of self-efficacy and filter adoption.

The purpose of this research is to gain a deeper understanding of factors that can be associated with the adoption of a relatively new household technology used for water treatment. The findings can not only assist Durabio in identifying a target audience and preparing marketing materials, but also should be beneficial for local health workers and WASH promoters who are interested in learning more about what may influence community members into investing in technologies that are known to improve health. The following chapter (Chapter 2), discusses previous studies related to the adoption of WASH technologies and the three themes of socio-economics, WASH characteristics, and the Health Belief Model. The chapter also provides background information on the study location and the SAWYER water filter. Chapter 3 provides details on the study's research methods and Chapter 4 presents a summary and discussion of key findings.

CHAPTER 2: PREVIOUS RESEARCH

Key information relevant to this study is presented in this chapter. Previous findings on the themes of socio-economics, WASH practices and characteristics, and the Health Belief Model as related to the adoption of water and sanitation technologies are presented in the beginning of the chapter. Then, a discussion about water quality, health, and habits in the study location is provided as contextual information for the reader. The SAWYER water filter's technology, operation and maintenance, advantages and disadvantages, and its emergence in Independencia are subsequently explained.

2.1 Adoption of WASH Technologies

Water, sanitation, and hygiene (WASH) interventions usually involve the promotion of two key aspects; a technology and the proper use of that technology. WASH technologies refer to any type of device, tool, or hardware that supports safe drinking water consumption, the control of human fecal contamination, or improved handwashing practices. Table 2-1 provides examples of several WASH technologies. While many reviews focus on the effectiveness of WASH technologies and generally support the conclusion that these interventions reduce the risk of diarrhea, a need exists to further understand what influences a user to adopt such technology (Hulland et al., 2015).

Table 2-1. Examples of WASH technologies promoted in developing world settings.

Household water treatment and storage	Filters, POU water treatment with chemicals, ultra-violet filtration devices, solar disinfection, boiling, improved water storage containers
Sanitation	Ecological sanitation systems, pit latrines, ventilated improved pit latrines, flush or pour-flush toilets connected to piped sewer systems, septic tanks (WHO/UNICEF Joint Monitoring Programme, 2013)
Handwashing	Soap, handwashing stations, hand sanitizers
Water supply	Hand pump technologies, rainwater catchment systems, improved wells, small-scale treatment and distribution systems (Hulland et al., 2015)

A systematic review published by the University of London's Evidence for Policy and Practice Information and Co-ordinating Centre (EPPI- Centre) in 2015 considered the following two research questions that are closely related to this study.

1) what are the factors that influence the sustained adoption of clean water and sanitation technologies?

2) what are the characteristics of interventions intended to improve adoption of clean water and sanitation technologies and how successful are these interventions at fostering both adoption and sustained adoption (Hulland et al., 2015)?

The study differentiates between factors that motivate initial adoption and factors that motivate sustained adoption. The research studied in this thesis focuses on the factors correlated to initial adoption, whereas the systematic review of Hulland et al. (2015) focused on the factors related to the sustained adoption of WASH technologies. These factors may not necessarily be the same, but are still vital for the research background. WASH interventions include handwashing, water treatment and sanitation. Factors found to influence sustained adoption as discussed by Hulland et al. (2015) are summarized in Table 2-2. In the results, the systematic review mentions all three themes that will be assessed in this study. Findings specifically related to water interventions are discussed in the subsections that follow.

Table 2-2. Factors identified that influence sustained adoption of WASH technologies (Hulland et al., 2015).

Psychosocial factors: psychological, social, or cultural.	• Perceived susceptibility, severity of disease, perceived benefits, perceived barriers • Nurturing and social norms • Pre-existing habits • Knowledge of the practice.
Contextual factors: background characteristics of	• Gender and age which greatly influence roles at the household level - who in a home typically provides water, soap, and childcare. • Socioeconomic status, education level, and gender.

Table 2-2. (Continued)

the location, setting, or individual.	• Existing infrastructure and prior exposure to interventions.
Technology factors: characteristics of a technology.	• Cost is the most important factor • Durability, rate of water flow, and maintenance.
Program characteristics: characteristics of the WASH intervention.	• Communication strategies are important - Frequent or personal contact with a WASH promoter over time - Personal follow-up combined with continuous communication - Support through mass media advertisements and group communications such as meetings, etc. - Interpersonal communication linked to sustained use and better recall.

2.1.1 Socio-economics and the Adoption of WASH Technologies

For both education and wealth indicators, studies have shown that their relation to adoption of WASH technology is strongly correlated in some circumstances and not in others. For example, a study based in Amhara (Ethiopia) found that the household heads adopting latrines were 1.9 times more likely to have any type of education than non-adopters (O'Loughlin et al., 2006). A similar study in Northern Ghana found that while latrine owners were similar demographically, they were more likely to report education or wealth indicators (Rodgers et al., 2007). In a study in Mali, educational training was not identified to increase the use of a locally-manufactured handwashing stations (i.e., a tippy-tap) while household wealth was determined to be a statistically significant factor in station use (Naughton, 2013; Naughton et al., 2015). Furthermore, in an initiative in rural Madagascar in which community-based sale agents promoted the purchase and use of a water disinfectant, no correlation was found to exist between literacy of the female head of household and use, or between per capita daily rice consumption (a measure of wealth) and use (Ram et al., 2007). Another study that took place in Bolivia found that most household characteristics (e.g., number of household members, years of household head schooling, presence of animals in kitchen, hand-washing behavior) had limited potential to predict the adoption of SODIS water filtration, demonstrating the complexity of behavior change (Christen et al., 2011).

The EPPI-Centre Review summarized in Table 2-2 found that higher socio-economic status was associated with use of POU treatment of water by chlorination (DuBois et al., 2010), use of Pureit filters (Freeman et al., 2012) and a filter used to remove arsenic (Inauen et al., 2013). The adopters of the Pureit water filters (Freeman et al., 2012) were found to have a significantly higher level of education than nonusers. In addition, a greater knowledge of the SODIS technology used to treat water was associated with higher education (Tamas and Mosler, 2011). One study also looked at the influence of religion and determined there was no significant difference between religions in the adoption of filters used to treat arsenic in Bangladesh (Inauen et al., 2013).

One case study from Senegal in which the Global Scaling up Handwashing Project employed a mass media campaign (Devine and Koita, 2010) used an image of a well-dressed mother to promote self-efficacy, social norms, habit, and nurturing behavior . That study suggested that access to mass media can also play a critical role in influencing the adoption of WASH technologies.

2.1.2 Access to WASH and WASH Practices and the Adoption of WASH Technologies

The EPPI-Centre review summarized in Table 2-2 also discussed the affect that seasonality can have on the adoption of a water treatment technology. It found that some users choose to only treat their water during the rainy season, when the quality of water is deemed to be worse (Wood et al., 2012). The review also linked WASH behaviors to previous WASH related experiences, suggesting that prior habits influence new WASH behaviors. For example, in Cambodia, it was found that handwashing and latrine access were linked to a user adopting water treatment with a ceramic filter (Brown et al., 2009). Furthermore, adoption of SODIS for water treatment was linked with latrine ownership in Bolivia (Christen et al., 2011), and practices like handwashing and safe water storage were linked with the subsequent adoption of water filters (Brown et al., 2009) and POU water treatment systems (Freeman et al., 2012).

Studies have shown a link between proximity to a water source and likeliness to adopt WASH technologies. In a study on handwashing in Mali, five indicators of soap usage, presence of soap, functionality, amount of water in the tippy-tap, and ground wetness under station were all found to be greater for tippy tap stations located near a pump or well (Naughton, 2013). In Bolivia, households that had adopted the SODIS water treatment method lived nearer to the water source (Christen et al., 2011). Finally, a meta-analysis by Wang and Hunter (2010) identified a relationship between distance to water source and health: the findings showed an increase risk of illness for people living farther away from their water source (Wang and Hunter, 2010).

2.1.3 The Health Belief Model and the Adoption of WASH Technologies

The Health Belief Model is a commonly used theory that helps to understand health behavior and potential reasons for adopting a recommended health action like treating water before consumption (Rainey and Harding, 2005; Vega, 2013). The Health Belief Model can help explain some of the motivations behind the early adopters who select to use a technology that reduces the risk of diarrheal disease. The first four perceptions were the original constructs of HBM, and the latter three were added on later as research evolved and the model expanded.

- Perceived Seriousness – An individual's belief about the seriousness or severity of a disease. Can be based on medical knowledge or from the beliefs about the effects it would cause.
- Perceived Susceptibility – An individual's subjective perception of the risk of actually acquiring a disease. When an individual believes a disease to be serious, that combines with perception of susceptibility is perceived threat.
- Perceived Benefits – An individual's opinion on the effectiveness of the new behavior or technology in decreasing risk of disease.
- Perceived Barriers – An individual's own evaluation of the obstacles that may prevent him or her from adopting the recommended behavior.

- Modifying Variables – The four constructs of perception change according to other variables which include but are not limited to; education level, past experiences, motivation, culture, skills, income level, etc.
- Cues to Action – Behavior can be influenced by cues to action, which can be events, people, or anything that stimulates someone into behavior change.
- Self-efficacy – An individual's confidence in one's own ability to successfully perform a behavior

In the EPPI-Centre review (Hulland et al., 2015) described in Table 2-2, 12 of 22 studies reported on perceived susceptibility to diarrheal and water-borne diseases and nine of these studies reported specifically on the perceived seriousness of water-borne and diarrheal diseases as influential factors in the adoption of sustained water treatment. Furthermore, a study examining technologies to remove arsenic from groundwater found that perceived risk and vulnerability to disease where higher among users of the technology than non-users (Inauen et al., 2013).

Nine of the 22 studies in the EPPI-Centre review (Hulland et al., 2015) reported on the perceived benefits of adopting a water treatment technology. Perceived benefits included health related benefits, technological benefits such as ease of use and convenience, benefits such as improved taste and smell of water (Ngai et al., 2007), and social benefits such as a change in social status. However, some users may dislike the taste of water after a particular treatment, therefore change in taste and smell can be both a benefit for adoption as well as a barrier to adoption (Hulland et al., 2015).

Studies suggest that cost is a frequent perceived barrier for the adoption of WASH technologies. For example, in an intervention in Guatemala in which households participated in a trial of a flocculant-disinfectant for treatment of water, the product was shown to reduce diarrhea prevalence by 39%, however, in a follow up evaluation, only 5% of the participants adopted the technology, with 41% choosing the high cost of the product as the main barrier to adoption (Luby et al., 2008).

One study in Bolivia suggested that the motivation to learn and adopt the SODIS water treatment technology is associated with family health concerns, like having an acutely malnourished child within the home. Those who were more likely to use SODIS were those who had repeatedly participated in promotional events (Christen et al., 2011). Findings from this study suggest cues to action can come from experiences within the home or from outside influences and can lead to the adoption of water treatment technologies.

The EPPI-Centre review emphasizes the importance of social norms in the adoption of a water treatment technology. Injunctive norms, or how individuals perceive others to approve or disapprove of their behaviors, were discussed as a motivator for adoption in 11 of the 22 articles reviewed. Eight of the 22 articles discussed descriptive norms, or what users perceive other people to be doing, and two studies described subjective norms, or how important others (respected people in the community) believe an individual should behave or perform. These social pressures from the community can thus be viewed as cues to action (Hulland et al., 2015).

While limited research on self-efficacy as related to the adoption of WASH behaviors and technologies exists, a strong sense of personal efficacy has been correlated to better health, greater achievement, and more social integration. Self-efficacy refers to a person's confidence in adopting the certain behavior, but is also related to an individual's sense of control over his or her environment and behavior (Schwarzer and Fuchs, 1995). A study in Bolivia found that the early adoption of SODIS technology could be significantly predicted by involvement in water issues (Moser and Mosler, 2008). In Bangladesh, deep tubewells provide an arsenic-free alternative to arsenic contaminated shallow tubewells. One study found that higher quantities of deep tubewell water used for drinking correlated to a greater perceived self-efficacy. The significant effect of self-efficacy in Bangladesh implies that people confident in their own abilities to carry out certain behaviors do so to a greater extent than those with less confidence (Mosler et al., 2010).

2.2 The SAWYER Water Filter

The SAWYER water filters function with hollow-fiber membrane technology, a system that was adapted from filters used for kidney dialysis. The filter functions strictly through mechanical exclusion, the system has no chemical treatment process. Membrane filtration is defined as pressure- or vacuum-driven process to remove particulate matter over 1 µm using a barrier, typically through a size exclusion mechanism (EPA, 2005). Membrane filtration includes mictrofiltration (MF), ultrafiltration (UF), nanofiltration (NF), and reverse osmosis (RO). The filtration type is characterized by its ability to remove particles based on pore size. The SAWYER PointONE is a microfiltration membrane filter and consists of a hollow-fiber module.

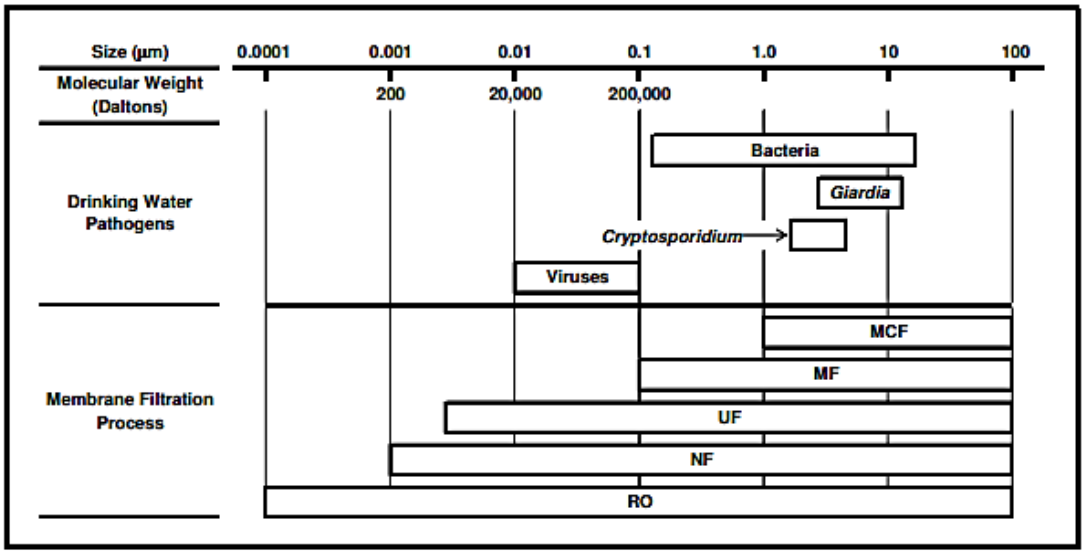

Figure 2-1. The approximate size ranges of bacteria, *Giardia*, *Cryptosporidium*, and viruses, and the abilities of each filtration type to remove them (EPA, 2005).

SAWYER partnered with a fiber manufacturer to improve its hollow fiber membrane technology in order to make a membrane that could withstand backwashing yet ensure the exclusion of particles over 0.1 µm (SAWYER, 2015). While the actual membrane material of the PointONE is unknown

(SAWYER will not disclose their formula), membrane materials are typically manufactured from a synthetic polymer. The material properties depend on the characteristics of the filtration device; the PointONE should have bi-directional strength for backwashing, and resistant to fouling in cases of very poor water quality (EPA, 2005).

The SAWYER filter module is constructed of long, narrow tubes made of synthetic polymers bundled together longitudinally, bonded on both sides, and encased in the pressure vessel. The water flows from "outside-in" meaning that the water passes from outside the fiber, through the fiber wall to the inside, where the water is collected in the lumen. This method maximizes surface area for filtration per fiber and avoids problems with clogging of the lumen bore.

The SAWYER PointONE filters are certified so 0.1 µm is the largest pore size; therefore preventing diarrhea-causing bacteria such as *E. coli*, cholera, and typhoid to pass through the membrane. The SAWYER filter can be adapted to sink, a bucket, any standard bottle, or to the plastic bottles that are included in the PointONE Filter kit. The filter can be used to purify water before drinking and the clean water can also be used to wash food that can be contaminated from the field, insects, or handling. The kit includes all items shown in Figure 2-2: the filter, the syringe required for maintenance, a hose that can connect to standard faucets, a hose that can connect to plastic containers, the hole cutter to make holes in plastic containers, and various accessories like the push-pull caps.

The SAWYER PointONE filter removes microbial constituents through mechanical exclusion. The pores of the fibers that constitute the membrane function as a sieving mechanism, retaining all particles larger than 0.1 µm that remained trapped. The filter does not remove all viruses because

Figure 2-2. Items included in the SAWYER PointONE All in One filter kit.

they are typically smaller than 0.1 µm. The EPA Membrane Filtration Guidance Manual describes a more complicated process than the simple concept of sieving used to illustrate the removal mechanism. Particles smaller than 0.1 µm may be removed through probabilistic interception at one of the pores smaller than 0.1 µm. In some cases, particles may be excluded due to electrostatic repulsion or adsorption to the membrane. A cake layer may also form during use, inadvertently increasing removal efficiency through the deposition of particles in the pore spaces (EPA, 2005).

Two independent reports published on SAWYER's website support SAWYER's claims of removing 99.99999% of all bacteria and 99.9999% of all protozoa. In a test conducted by Hydreion Labs in Canada, suspensions of the parasites *Giardia lamblia, Cryptosporidium parvum* and the bacteria *Klebsiella terrigena* at concentrations of 1.0×10^7 cysts/L, 1.0×10^7 oocysts/L, and 2.0×10^8 cells/L respectively were passed through three SAWYER PointONE filters. The report cited a >6-log reduction for bacteria and >5-log reduction of the two parasites because the concentrations in the effluent water were non-detectable (Hydreion, 2005). A similar test conducted at Messiah College used surrogate organisms of similar size to fecal coliforms, *Cryptosproridium* and *Giardia,* to test the effectiveness of three filters.

Two of three filters had detectable levels of all three contaminants in the treated effluent ranging from 1-4 cfu/100 mL, but in all tries, the filters achieved a >6-log reduction (Erikson et al., 2014). It was stated that this reduction met the reduction requirement for bacteria and protozoan cysts for a water purifier as described in the United States Environmental Protection Agency's Guide Standard and Protocol for Testing Microbiological Water Purifiers (EPA, 1987). The regional government of Loreto, Peru's northernmost region, also conducted laboratory testing to verify SAWYER's claims. The regional government's office of environmental health tested the filter using a sample from the Morona Cocha Lake. Although the report does not discuss methods, the test results which are included Appendix A showed a reduction in turbidity (from 5.37 NTUs to non-detectable), a reduction in total coliforms ($3.5x10^6$/100 ml to non-detectable) and a reduction of *E. Coli* ($1.7x10^6$ to non-detectable.)

A recent study (Murray et al., 2015) raised question about SAWYER's claims of the PointONE All in One Filter having a Lifetime Warranty (SAWYER, 2015). Between 2010-2013, Pure Water for the World installed more than 200 PointONEs in Honduras. In follow-up testing, more than half of the 29 filters distributed in one community produced effluent with >10 CFUs of *E. Coli* per 100 ml, which is considered an intermediate to high health risk by the WHO (WHO, 1997). Six of these filters demonstrated >99.6% mean *E. coli* removal efficiencies and 98-99% mean turbidity removal efficiencies when tested shortly after distribution and were showing much lower removal efficiencies 21 months later: i.e., 54% for *E. Coli* and 59% for turbidity. These six filters were thus removed from the field and subjected to laboratory testing to investigate their reduced performance. In those laboratory tests, sterile water was passed through the 6 used filters and 1 new filter. The water passed through some of the used filters was found to have high turbidity (i.e., 3 out of 6 used filters had turbidity >200 NTUs) and bacterial loading (i.e., 4 out of 6 used filters with >13 CFU/10 ml, 1 sample had effluent that too numerous to count and one filter had water that did not pass through.) The study identified pore blockage due to irreversible fouling as well as broken membrane filter fibers (Murray et al., 2015). A

review of the Murray et al. article published in the same journal (Lindquist et al., 2015) called into question several elements of the study including the storage conditions pre-analysis, the sample size and method and the claim of broken fibers. The most arguable point in the Lindquist et al. (2015) review is that the 6 filters studied were specifically selected due to poor performance and therefore were not a representative sample. In addition, the authors stated that the filters remained untested for two months after being collected from a tropical region and sealed in a plastic bag (Lindquist et al., 2015). Murray et al. (2015b) published a response to that review in which they suggest that SAWYER's lifespan claims may not be suitable for more demanding developing world settings.

Two studies have reported similar findings as Murray et al. (2015). First, in a study performed in the Peruvian Amazon, SAWYER filters were used for a pilot project in which the filter was the second step in a two-step process to clean water directly from the river. The first step involved using alum to reduce the water's turbidity before passing it through the SAWYER filter. The study highlights the importance of a first pretreatment step if the raw water is very turbid in order to put "less stress" on the filter. The researchers used the Aquagenx Compartment Bag Test to test water at three points: after the pretreatment (point 1), after passing through the filter (point 2), and from the storage container (point 3). Results showed an improvement in water quality between testing point 1 and 2, yet still 39.1% of samples taken directly from the filters were positive for fecal contamination only three months after installation (Brune et al., 2013). In the second field study performed in Fiji, the hydrogen sulfide (H_2S) paper-strip test method was used to test 24 water samples for bacterial indicators of fecal contamination obtained from SAWYER filters. Results from 17 of the 24 samples were shown to be contaminated and 13 of them were determined to be "highly contaminated." In that study, 61% of respondents reported using untreated water for backwashing, providing a possible explanation for such high amounts of fecal contamination in field studies (Jeremy et al., 2013).

For users with running water, the most convenient method of operating the filter is to attach it directly to a faucet. For those without continuously running water, the preferred option is to connect the filter to an elevated bucket using the adapter. For individual users or users on the go, the filter can be attached to the pouch included in the kit or to a standard plastic bottle. SAWYER water filter flow rates are highly variable and depend on several factors including the head pressure, altitude, natural variability between filters, how recently and thoroughly the filters have been backwashed, and the connection type. Table 2-3 provides the expected flow rates for several scenarios based on elevation, full to empty or constantly full, 19 Liter bucket or 208 Liter drum, and the circumference of the connection hose.

Table 2-3. Expected flow rates for the SAWYER PointONE for different use scenarios.

		Sea Level		**1,220 M**		**2,135 M**	
Full to empty		Liters					
19 Liter bucket		per hour	per day	per hour	per day	per hour	per day
	30 cm Hose	46.5	1117	40.2	964	32.8	787
	91 cm Hose	73.5	1764	67.5	1523	51.8	1244
208 Liter Drum							
	30 cm Hose	60.2	1445	52	1248	42.4	1019
	91 cm Hose	84	2017	72.6	1741	59.2	1422
Constantly Full							
19 Liter bucket							
	30 cm Hose	53.9	1295	46.6	1118	38	913
	91 cm Hose	78.2	1876	67.5	1620	55.1	1323
208 Liter Drum							
	30 cm Hose	81.3	1951	70.2	1685	57.3	1376
	91 cm Hose	99.2	2381	85.7	2056	69.9	1679

Adapted from SAWYER's PointONE™ Filter full flow rate report (U.S. and metric) (2013).

The larger the pressure head, the faster the flow through the filter, so in the context of Independencia, a higher storage tank will result in more head and thus a greater flow rate which should

result in a more satisfied user. In one study, 80% of filter users who reported having problems with the filter cited reduced filter flow rates and blockages as the principal negative issue. That study also observed that families who used highly turbid water, often times from a river, experienced greater and more frequent blockages (MAP International - Ecuador, 2012). In a pilot study in the Peruvian Amazon, participants used untreated surface water from rivers or streams and were required to have a pretreatment step to prevent the filters from clogging too quickly (this pretreatment step has been discussed in Mihelcic et al., 2009). The results of the pilot study noted that the advertised expected flow rates were based on testing that used waters with low turbidity, in contrast to the highly turbid surface waters used the pilot study. Of the households that participated in that study, 55% reported high flow rates, 35% slow flow rates, and 6% reported that the flow rate was too slow (Brune et al., 2013).

A study on the Tulip ceramic filter found that pond water did not achieve the manufacturer's expected flow rates for the filter while synthetic water did, indicating inconsistencies in filter performance based on water quality. Because of the particle size distribution of the pond water (high concentration of particles below 0.5 μm), the pores of the ceramic could have clogged faster, causing this discrepancy. It could have also been caused by the presence of natural organic matter or chemical constituents not accounted for in the synthetic water (Renzi, 2011). It can be assumed that filters that function with exclusion mechanisms can suffer from similar performance issues as the Tulip filter, even more so in the field.

A decreased flow-rate is an indication that the pores of the membrane are clogging and the filter requires maintenance. Maintenance is completed by backwashing the filter. By reversing the flow, the particles clogging up the filter pores are pushed out of the opposite end. Backwashing is completed by unscrewing the (optional) push-pull cap from the filter, filling the syringe with previously filtered water, and pushing the clean water backwards through the filter with force. This can be done repeatedly until the water exiting is clear. One study noted that in laboratory tests, the flow rate improved when the

filter was backwashed six to nine times (Brune et al., 2013). In Murray et al. (2015), the researchers even contacted SAWYER for suggestions on cleaning procedures beyond backwashing with filtered water. In that case, SAWYER recommended soaking the filters in hot water for 30 minutes, backwashing several times with deionized water, soaking them again in white distilled vinegar, then repeating the backwash with the deionized water (Murray et al., 2015b). The efficacy of this cleaning method in restoring flow rates was however not reported by the study authors.

The SAWYER PointONE water filter is reported to have several advantages over other POU water treatment technologies. For example, because of its small size, it is portable and highly adaptable to different water sources. It can be set up within a home or carried throughout the day. Community members also do not need to rely on a centralized water system to provide clean water; any source of fresh water can serve as the water source to the filter. The filter also has no movable parts to break, no cartridges to replace, and requires no power source. The maintenance is simple and its frequency depends on use and water quality. By using the filters, the water also does not require the chemical treatment of chlorine which alters the taste, nor does the water retain a flat taste like it does when it is boiled. Furthermore, in Independencia, families rely primarily on gas and in some cases electric boilers or fire wood to boil water. Boiling can be costly and time consuming, especially for larger families. In cases where fire wood is needed, it can be harmful to the environment because of deforestation and can reduce indoor air quality.

In a developing world setting, the greatest disadvantage of the SAWYER water filter may be the high initial cost. Families may struggle to pay for a technology that costs approximately US$100, making it difficult to purchase up front. Another disadvantage is that the SAWYER filter cannot withstand freezing temperatures which is not an issue in coastal Peru but could be a problem in the mountainous regions of the country. Online reviews cite the lack of an activated carbon or chemical treatment component for improving taste as drawback of the SAWYER water filter (Trailspace Outdoor Gear

Reviews, 2013). Another reported disadvantage that could present a problem during Peru's rainy season is the filter's limited capability to deal with highly turbid water. Not only does the filter clog quickly in a high turbid water, but the filter's continuous use with high turbid water may dramatically reduce filter performance over time (Goeb, 2013). A pre-treatment step may be necessary to deal with highly turbid water. Another disadvantage of the SAWYER water filter is the lack of residual protection which can lead to recontamination in cases where filtered water is being stored.

Finally, in a follow-up study of an initiative by Give Clean Water, Inc. in which 270 households and 6 schools were surveyed on filter use, 22% of participants reported being unable to use filters due to broken or missing parts. Participants in the study were also observed having difficulty properly washing the filters (Jeremy et al., 2013). The backwash syringe may also be a disadvantage to PointONE users because of the observed difficulty to use in the field and because it can be lost easily.

2.3 Background on Study Location Independencia and Water, Sanitation and Hygiene

The district of Independencia is located 250 kilometers south of the Peruvian capital of Lima. Independencia, highlighted in yellow in Figure 2-3 a, is one of eight districts in the Pisco province, highlighted in red in Figure 2-3 a. The Pisco province is located within the in the region of Ica, shown in red in Figure 2-3 b, directly to the south of the region of Lima. The district is spread over 272.34 km^2 in the Pisco Valley and ranges from 125 to 950 meters above sea level climbing up into the Andes foothills towards the east. The district capital of Independencia, also known as Independencia sits at 203 m above sea level. The climate is temperate desert. Precipitation in Independencia averages 15 mm annually (Gómez, 2008) unless affected by El Niño, the weather phenomenon that causes rain in the Peruvian deserts. The estimated population for the district in 2014 was 14,173 inhabitants where 30% live in urban areas and 70% live in rural areas. The primary economic activity is agriculture, with an estimated 77.6% of the economically active population (only 46.5%) being involved in this sector (Gómez, 2008).

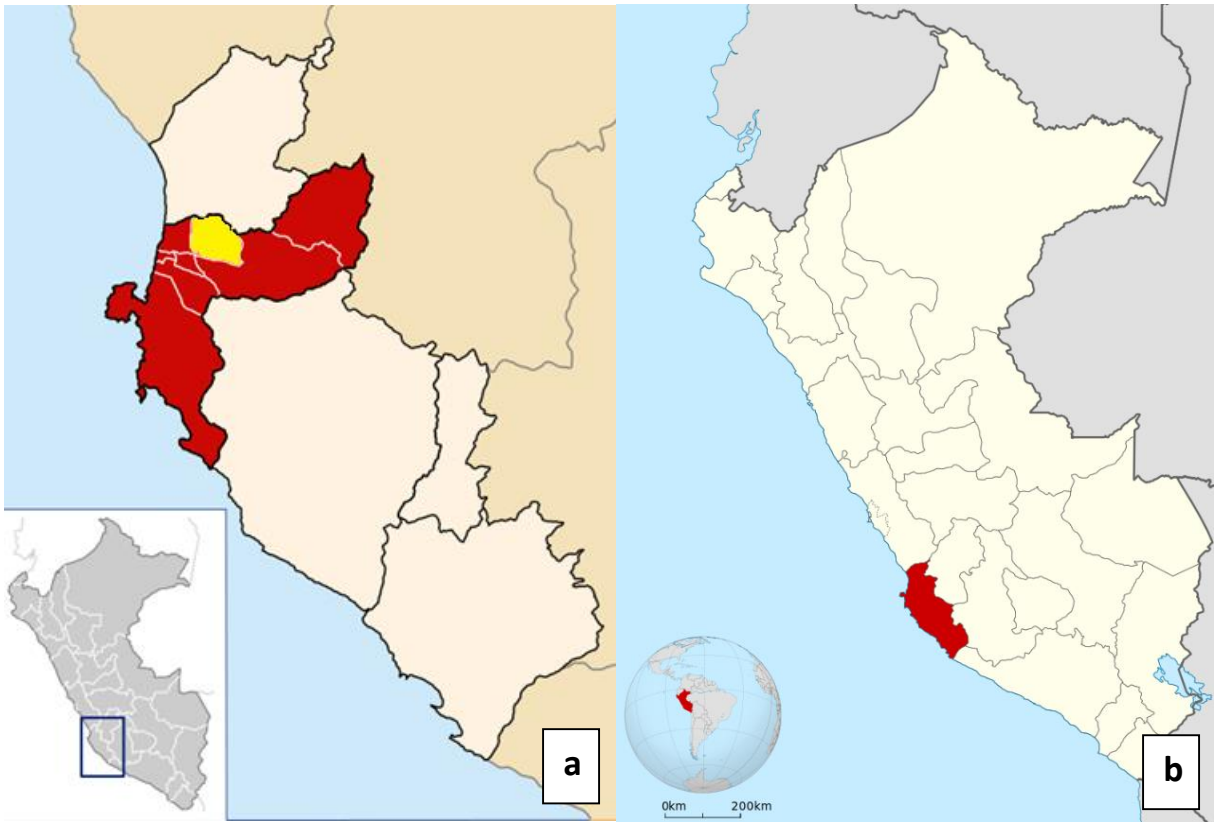

Figure 2-3 a) Map of the Ica region in Peru showing the Pisco province highlighted in red and the district of Independencia highlighted in yellow. b) Map of Peru with the region of Ica highlighted in red. Used with permission from Wikicommons.

2.3.1 Water Quality in Independencia

In 2011, Peru's Ministry of Health published "Regulations of Water Quality for Human Consumption." Signed into law by ex-president Alan Garcia, the document set water quality standards, gave greater responsibility to regional governments with respect to water quality monitoring, and established the National Office for Environmental Health (DIGESA) as the principal authority in the country for health issues related to water. In theory, 87% of the Peruvian population with access to an improved water source should be receiving safe drinking water, but in reality, that is not the case.

In Independencia, water quality is monitored by government employees responsible for environmental health. The district has five health posts, and at each health post, someone is responsible

for conducting house visits and measuring the level of chlorine in the water at least once a month. These reports are then to be sent to the Hospital San Juan de Dios in Pisco, where the Office of Environmental Health monitors the reports and takes action when standards are not being met. One item to note is that turbidity, which affects the effectiveness of chlorine, is not tested.

In a test conducted by the Direccion Regional de Salud (DIRESA) in December 2013, four samples were taken from several points throughout the water system and measured for chlorine and coliforms. All the samples tested resulted in non-detectable amounts chlorine. The sample from the reservoir measured 4.5 MPN/100mL for coliforms and up to 240 MPN/100mL from a household in the network. Throughout the rainy season in the Andes which lasts from February to May, sediment and contamination is introduced to the Pisco River that causes an increase in turbidity. The water in the bucket shown in Figure 2-4 is a photo of a water sample collected directly from a household tap in Independencia during this period and shows the presence of turbidity.

Figure 2-4. Water in the bucket obtained from the municipal tap in Independencia during the rainy season shows high turbidity.

In addition to the upstream contamination, the distribution system is susceptible to recontamination due to its proximity and sometimes overlap to the irrigation canal as seen in Figure 2-5 a, proximity to the wastewater collection system in areas that have access to it, and unconventional maintenance practices by the municipal workers. Figure 2-5 b also shows a hole which had been poked in a distribution pipe in an attempt to pinpoint a blockage in the system. The hole was then plugged with a stick and reburied. Figure 2-5 c shows a piece of pipe that was cut to remove an obstruction that was then haphazardly reconnected with the pipe fitting pictured. With her experience working as a PC volunteer, the author has witnessed similar water conditions and maintenance practices along coastal Peru.

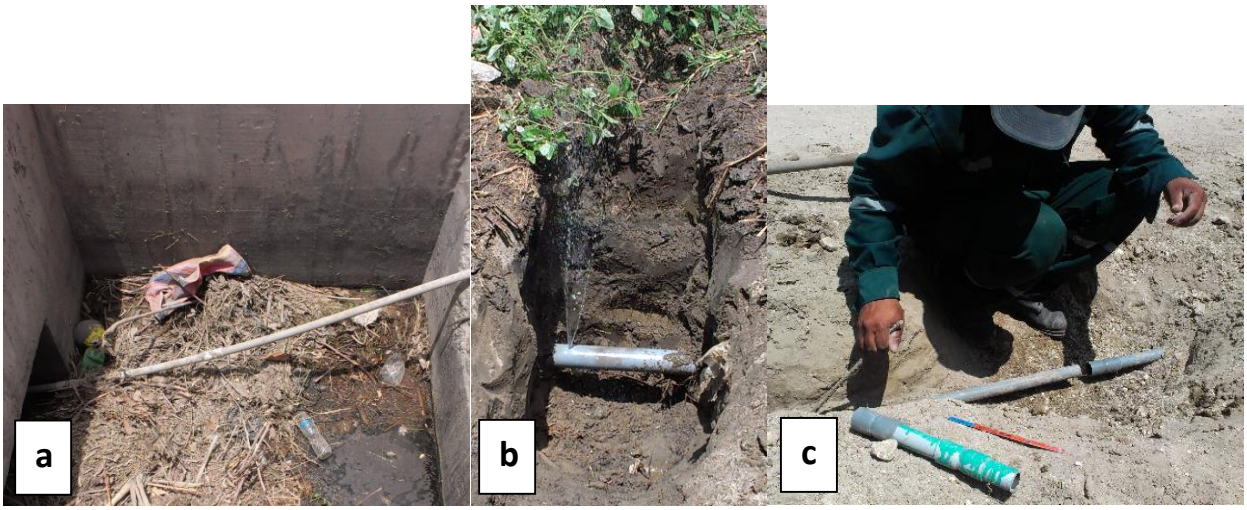

Figure 2-5. a) A water distribution pipe overlaps with the irrigation canal. b) A pipe is unearthed and a hole is poked in it to find the location and cause of a water blockage. c) A water technician prepares to reconnect a pipe that had been cut to remove an obstruction.

2.3.2 Water and Health in Independencia

In the District of Independencia in Pisco, POU treatment for water is practiced by the majority of residents, with most people reporting to boil their water or chlorinate before consumption. Out of 40 surveys conducted in two communities by the researcher in early 2014 as part of her Peace Corps

Service, 100% of persons interviewed reported to boil their drinking water. In a previous study conducted by a Peace Corps Volunteer serving in Independencia, 84 homes were surveys in three communities, and results showed that 80% of those surveyed treated the water, mostly with boiling (McKenzie, 2011).

Results show that Independencia's general population knows to treat the water in some way, but survey responses and health post statistics indicate that diarrhea rates are high. For example, out of 40 households surveyed by the researcher as a Peace Corps Volunteer, there were 24 children under five, and 10 had suffered from diarrhea in the month previous to the survey (42% of children.) In the 2011 study by the Peace Corps Volunteer (McKenzie, 2011), 18.6% of the households with children under 5 reported to have diarrhea in the previous month, but the number of children per household was not provided. In 2013, the district's main health post located in the district center (4 others are dispersed throughout the district) reported 205 cases of diarrhea, the second most reported reason for a doctor's visit. More than half of these cases were in children under five. The third most reported reason to seek medical attention as reported to his study's author was typhoid, with 64 cases.

Diarrheal diseases are a public health issue in Peru not just because of the quantity, but because of the impact that repeated diarrhea has on the nutrition of children under five years of age. This is because malnourished and underweight children are more vulnerable to infectious diseases and are less likely to fully recover from these diseases (Prüss-Üstün et al., 2008). Diarrhea and malnutrition also affect the physical development of a child through the reduction of weight and height gains, but long term effects of diarrhea and malnutrition extend beyond short stature; these can include impaired fitness, schooling, fluency and cognition, and the malabsorption of drugs needed to combat malaria and tuberculosis (which often coexist with malnutrition and diarrhea) and those needed to combat AIDS. (Guerrant et al., 2008)

2.3.3 Durabio in Independencia

In September of 2014, the study author met Durabio's C.E.O. in Lima, Peru. After discussing her work as a Peace Corps volunteer and her familiarity with WASH in Peru, they decided to form a partnership. Towards the end of 2014, the thesis author spoke to a friend who had previously held a job at Independencia's water office about the SAWYER PointONE water filter. Being familiar with the water quality issues in the district, she and her husband obtained one for her family straightaway. After using the filter for a period of several months, the couple decided to sell them since the husband is a well-known salesman in Independencia and the wife had experience in water quality. They began offering the filters to neighbors and friends and then attempting to take sales a step further by promoting the product at fairs, as seen in Figure 2-6, and information sessions throughout the town. They created flyers and posters and did demonstrations at institutions, in homes and even in the streets in an attempt to promote the product.

Figure 2-6. A SAWYER PointONE filter demonstration at a local agricultural fair.

CHAPTER 3: METHODS

This research study took place in several districts within the region of Ica in Peru (Figure 2-3 b). The District of Independencia located in the province of Pisco (Figure 2-3 a) was the primary location of the study and is where the thesis author served as a Peace Corps WASH volunteer between 2013-2014. Several interviews took place outside of Pisco, in the provinces of Ica and Palpa, located to the south of Independencia. The reason for this was that the use of the filters purchased in Independencia is not limited to the district. Many people work in Independencia and spend a lot of time in the district but do not actually live there; therefore some filters were purchased in Independencia but used in other communities. Nine communities, listed in Table 3-1, were visited to investigate the adoption of the SAWYER water filter, four of them within the district of Independencia.

All communities involved in the study are part of the coastal region of Peru and speak Spanish as their primary language. The research methods described below were approved by the Institutional Review Board (IRB) at the University of South Florida on September 15th, 2015 (See Appendix B). The research was determined to be of minimal risk to participants. To ensure that the language used in the survey was understandable and relevant to the population, the study's author employed the help of several staff members at the district municipality to read and revise early drafts. All participants in the study were over the age of 14 and used a filter purchased from a sales representative in Independencia. The sales representatives (described in Section 2.2.3) and the thesis author worked together to log the names and phone numbers of each person who purchased a filter. Each person was contacted by phone or in person and was asked if they were willing to participate in the study. If they agreed, the researcher set a time to visit at their house to conduct the survey. Upon arriving at the household, the thesis author obtained written consent forms for adults and written consent and parental consent for participants

aged 14-18. Participants had the option to opt out of having the meetings audio recorded. In a few cases, the participant could not read the survey so the survey was completed with the thesis author or a family member making the statements and writing down the participant's response. In most cases, both parts of the survey took place during one house visit in which the author interviewed all members of the household over 14 that actively consume water filtered with the SAWYER PointONE. In some cases, the author returned at a later date to interview members of the household who were not present during the initial visit. Two participants opted out of the house visit and instead met the thesis author at a public location.

This research utilized qualitative research methods which included a multi-part survey. First, an adult in the household answered a questionnaire delivered verbally to collect household demographic and socio-economic information, data related to WASH access, and questions about the purchase and use of the filters. The household information collected (shown in Table 3-1), included a series of questions that are used to calculate a Progress out of Poverty Index® (PPI®) score. The PPI® is a poverty measurement tool that uses ten questions on household characteristics and asset ownership to compute a number that measures the likelihood that a household is below the poverty line. The most recent version of the PPI® in Peru was updated in 2012 and is based on the 2010 Encuesta Nacional de Hogares (ENAHO) or the National Survey of Homes, conducted by Peru's Instituto de Estadística e Información (INEI), the Institute of Statistics and Information. The original PPI® survey for Peru (found in Appendix D) was incorporated into the verbal household questionnaire portion. The verbal portion also included personal demographic questions, specific questions about hand hygiene, and six open-ended questions based on the Health Belief Model, shown in Table 3-2.

Table 3-1. Information collected on the household surveys.

Household demographic information	PPI survey	Household WASH access	Household filter information
Community, district, province	House size	Municipal water connection?	Filter purchase date
Rural or urban	Number of household members over the age of 14 who have worked in the past week	Running water within the home?	Payment method
Married, single, or cohabitating	Number of rooms used exclusively for sleeping	Water storage within the home	Installation help?
Highest schooling, female head of house	Material of exterior walls	Treatment type before filter	Currently installed?
Highest schooling, male head of house	Main combustible used for cooking	Underground water storage?	Installation type
Temporal, independent, or permanent work	Refrigerator/freezer	Roof water storage tank?	Number of people who consume water from filter
Vehicle possession	Blender	Sanitation type	Who is responsible for maintenance?
Main source of income	Number of color TVs	Sewer connection	How often do they clean the filter?
Media access	Cell phone	Shower, sink, and toilet?	Ever used something not included in the kit? If so what?
			Filtered water storage

Table 3-2. Personal data collected in the verbal questionnaire.

Personal information	**Personal hygiene**	**Open ended HBM questions**
Gender	Critical handwashing moments	What are some of the consequences of you or your children having diarrhea?
Religion	How do you wash your hands?	Can you give examples of illnesses related to low water quality?
Age	Soap use	What benefits did you see in the filter that led you to use it?
Place of birth	Where do you wash your hands?	Did you have any doubts about using the SAWYER filter?
	Handwashing station type	Was there an action, sign, or experience that convinced you to try the SAWYER filter?

The second part of data collection involved a written survey of 30 questions to asses factors related to Health Belief Model. In the survey, participants responded by choosing responses on a Likert scale from “strongly agree” to “strongly disagree” for 24 statements related to the HBM and by also answering the same five open ended questions in Table 3-2. Four statements were included for each Health Belief Model construct: perceived seriousness of water related illnesses/diarrheal disease, perceived susceptibility to water related illnesses/diarrheal diseases, perceived benefits of adopting the SAWYER water filter, perceived barriers to adopting the SAWYER water filter, the cues to action that may lead to the adoption of the SAWYER water filter, and the self-efficacy of filter users. Table 3-3 shows an example of a statement for each Health Belief Model Construct. The complete household survey and personal survey can be found in both Spanish and English in Appendix D.

Throughout the process of conducting the surveys, some questions were deemed to be confusing or had the potential to be understood in different ways by the participants. Each question is discussed in the Results, as are the frequencies and interpretations of results, including those that were unclear. Although the dialogue during this portion was not recorded, the researcher would sometimes have discussions about a question and encourage the participant to write down any extra thoughts or opinions they may have had.

Table 3-3. Sample statements from the Likert Scale Health Belief Model Survey.

Health Belief Model Construct	Sample Statements
Perceived Seriousness	Diarrheal diseases threaten the health of children
Perceived Susceptibility	Drinking untreated water does not risk my health
Perceived Benefits	The SAWYER filter saves me money in the long run
Perceived Barriers	I don't like to have to adapt to a new technology
Cues to action	The water turbidity during the rainy season led me to look for another form of water treatment
Self-efficacy	I can find a way to pay for my health needs

This study completed 39 interviews in 9 communities in 5 districts located throughout the region of Ica. The locations of the households surveyed are listed in Table 3-4. Two of the houses were not visited, rather the researcher met the head of household at a public location. All sites outside Independencia were reached on public transportation and are easily accessible from the Pan-American Highway. All sites, which are pictured on the map in Figure 3-1, were within a 2-hour commute from Independencia. All surveys were conducted between September 16 – 22, 2015.

Table 3-4. Centro Poblados visited for household visits and the number of interviews that took place at each site.

Centro Poblado	District	Province	Number of interviews
Manrique	Independencia	Pisco	14
Toma de Leon	Independencia	Pisco	4
Independencia	Independencia	Pisco	3
Santa Isabelle	Independencia	Pisco	3
San Andres	San Andres	Pisco	1
Parcona	Parcona	Ica	6
Subtanjalla	Subtanjalla	Ica	3
Santa Elenta	Ica	Ica	1
Rio Grande	Palpa	Palpa	4

Figure 3-1. Map showing locations of household visits.

All data collected for this study was manually inputted into an excel spreadsheet and interviews were transcribed. For all statistical analysis, data were inputted into SPSS and the appropriate analyses were performed. Inferential statistics could not be used to assess all of the objectives; for these other objectives, descriptive statistics were used to make conclusions about the data. The chi-square goodness-of-fit test was used to compare the 15 households surveyed to the general population for the objectives that had reliable comparison data; PPI, education level, rural or urban, cable, internet and computer access, water and sewer connection. The chi-square goodness-of-fit test is used to determine if observed proportions in two or more categories of a categorical variable differ from what is expected

a priori. In this case, the a priori comparison proportions, π, were collected from several sources (e.g. CIA World Factbook and INEI) and represented the national (Peru) or regional (Ica) population.

For the chi-square test, the hypothesis is:

H_0: The data from this study follows the distribution of the comparison population

H_a: The data from this study does not follow the distribution of the comparison population

where the test statistic X^2, is calculated as:

$$X^2 = \sum_{i=1}^{k} (O_i - E_i)^2 / E_i \qquad \text{(Equation 3.1)}$$

where O_i is the observed frequency and E_i is the expected frequency.

The chi-square goodness-of-fit test is based on two assumptions: 1) independent observations and 2) an expected frequency (E_i) of at least 5 per category. In SPSS, the probability, *p*, provided in the output is based on an asymptotic approximation which is not reliable when the E_i's are small. The assumption of independent observation is violated because the study sample is not random. The data is specific to SAWYER water filter users who obtained a filter in Independencia. Also, because the sample size (N = 15) for households in this study is small, the assumption of an expected frequency of 5 was repeatedly violated when performing the chi-square goodness-of-fit test. To account for this violation, one of SPSS's two Exact Tests (Monte Carlo and Exact) were used. The Exact Test is provided as an option under "Exact" under non-parametric tests - chi-square in SPSS. The Exact Test, based on the Fisher's Exact method, allows researchers to make reliable inferences with small sample sizes. The Exact Tests provides a *p* value without making assumptions about sample size, *N*, or a priori probabilities, π (Mehta and Patel, 2011). For all of the statistical tests, a significance of α = 0.05 was used. For all *p* values less than 0.05, the null hypothesis is rejected and the alternative hypothesis that the sample of households that use SAWYER water filters is significantly different from the general population is accepted.

CHAPTER 4: RESULTS AND DISCUSSION

As discussed in Chapter 1, the goals of this research were to: 1) assess if SAWYER water filter users have a high overall socio-economic status, 2) assess if SAWYER water filter use can be associated with access to water and sanitation and proper hygiene and water habits, and 3) determine which Health Belief Model factors are associated with filter adoption. Through personal interviews and household surveys, the author gathered socio-economic and demographic information, information about access to water and sanitation and hygiene habits, data related to health belief model constructs, and general information about filter purchase, use, and maintenance. Compiling all this information and analyzing the data should provide deeper insight into the perceptions and motivations of SAWYER water filter users. The following results will benefit Durabio in knowing more about its customer base, but may also assist health workers by providing information on a water treatment technology's early adopters in order to develop new strategies to promote health behaviors based on findings.

4.1 Descriptive Statistics

Fifteen households were surveyed, 12 of which have their own filter, and three of which have members who use the filter at another house or borrow the filter. The households had begun to use the filters at different times: one household had been using the filter for 8 months at the time of the study, while one other had been using it for less than a week. One house in Parcona (Ica), was a building with several apartment-type units in which several families (all related) live; however, the filter was used primarily by the members of one family living in the unit where the filter was connected. Two other filter users from the building were also interviewed, but did not complete individual household surveys. The mean household size of the houses surveyed was 3.94 people per house, with 0.313 children under 5 years old and 0.875 children between 5-17 years old. Most of those surveyed were Catholic, 84.85%,

while the remaining participants were evangelical Christians, Agnostic, or Mormon. Socio-economic and demographic information related to the goals and hypothesis are discussed in the following sections.

4.2 The Socio-economic Status of SAWYER Filter Users

4.2.1 Progress Out of Poverty Index (PPI®)

The PPI® score was the main tool used to measure socio-economic status. A PPI® score is determined from a ten question survey (see Appendix C). Based on household responses, a point value is assigned for each question and then totaled for a final score of the household's relative wealth. Based on the final score, the PPI® lookup tables (Appendix C) show the percent likelihood of a household with that score to be under the poverty line. The PPI® scores for the 15 households surveyed are provided in Table 4-1.

Table 4-1. PPI scores of houses surveyed and their percent likelihood of being below the national poverty line. Houses highlighted in bold blue indicate that they borrow but do not own a filter.

House number	PPI score	Percent likelihood of household below 100% National poverty line
1	64	3.6
2	69	1.5
3	**70**	**0.7**
4	77	0
5	75	0
6	67	1.5
7	74	0.7
8	76	0
9	72	0.7
10	81	0
11	58	8.1
12	**91**	**0**
13	**66**	**1.5**

Table 4-1. (Continued)

14	81	0
15	77	0

The information in Table 4-1 shows that based on the PPI® scoring, most of the houses surveyed have a very low likelihood of being below the poverty line in Peru. In fact, out of the 15 households, only one has above a 5% chance of being below the National poverty line. In comparison, in 2013, 23.9% of Peruvians were estimated to be living below the poverty line (The World Bank, 2015). When assuming a binary system where 0 indicates above the poverty line because the PPI score indicates a zero percent chance of being below the poverty line and 1 for any household with a chance of being under the poverty line, the exact test for goodness-of-fit indicates a significant difference in the proportion of households in poverty in this test study (53%) and the national percentage of 23.9%, $p = 0.013$. According to these results, the poverty percentage is much higher for the study sample than the national average, but when assuming that in a binary system, 1 indicates less than a 5% chance of a household being below the poverty line, and 0 indicates a house with a greater than 5% chance of being under the poverty line, the results show a different outcome. The proportion of houses under the poverty line is much lower (6%), and the exact test for goodness-of-fit test shows no significant difference from the national percentage of 23.9%, $p = 0.14$. By changing the assumptions, the exact test results indicate that the households in this study are above the poverty line at a greater proportion than the national average or that there is no difference, making it difficult to come to a conclusion on socio-economic status based on the PPI® scores alone.

The fifth question in the PPI® survey asks about the type of material that makes up the exterior walls of the household. In Peru, 51.7% of the homes have exterior walls made of brick or cement blocks and 0.6% have stones or ashlar with lime or cement. These materials are known as “materiales nobles,”

or noble materials in Peru, and are indicative of higher quality materials used for the construction of the home. The PPI® also includes wooden walls in this category which make up 7.7% of exterior walls in Peru and are worth the same amount of points as noble materials. Only one of the 15 households surveyed did not have exterior walls made of noble materials. The exact test shows that the proportion of houses with walls of noble material in this study (93%) is significantly different from the national percentage of 60%, $p < 0.001$. These results support the conclusion that SAWYER water filter users have a higher socio-economic status than average Peruvians because they generally have houses made with higher quality materials than the overall national population.

4.2.2 Education Level of Head of Households

All of the heads of households that use SAWYER water filters were found to have at least a high school education and over half have what is considered a superior education (i.e. they have a non-college post-secondary degree, a college degree, or post-graduate degree). Table 4-2 shows the average level of education obtained by males and females in Peru as compared to the level of education obtained by the heads of households in this study's sample. On a national level in Peru, men are slightly more educated that women overall; about 3.4% more men have a university or post graduate degree than women. The women who participated in the study have a significantly different level of education than the national data, $p = 0.006$. The percentage of women with a superior degree (33%) is above two times the national percentage of 14.2%. Nationally, only 14.3% of adult women have a university degree, which is less than one third of the 53.5% of women in this study who had a university or post graduate degree. The male heads of households that used SAWYER filters were also more educated on average (30.1%) have a university degree) than the national average, but not to the same extent as the women. The exact test for goodness-of-fit test did not find the men in this study (15.4%) to be significantly different in levels of education than the national population, $p = 0.866$. In five of the

households surveyed, the female head of house was more educated than the male head of house, and in two households there was no male head of house.

Table 4-2. Percentage of education level obtained on a national scale in Peru as compared to head of households who had adopted the filter and were surveyed.

	No level or elementary		**Primary**		**Secondary**		**Superior, non-university**		**Superior, university or post graduate**	
	National	Study	National	Study	National	Study	National	Study	National	Study
Male	2.4	0	24.9	0	40.8	53.8	14.3	15.4	17.7	30.1
Female	9.4	0	29.7	0	32.5	13.3	14.2	33.3	14.3	53.5

4.2.3 Marital Status

Table 4-3. Ages and marital statuses of heads of households. Households in blue bold fall outside of "reproductive age" as defined by the Child Trends Report. For marital status, M is married, C is cohabitating, and S is single.

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Age F	42	**59**	28	34	48	**57**	**76**	48	45	**55**	32	46	30	**54**	**51**
Age M	45	**58**	32	31	46	**X**	**76**	56	47	**55**	38		40	**50**	
Status	M	**C**	C	M	M	**C**	**M**	M	M	**C**	M	S	M	**M**	**S**

As shown in Table 4-3, in 9 of 15 (60%) of the households surveyed, the heads of household who had adopted filers were married, 4 of 15 (26.7%) were cohabitating, and 2 of 15 (13.3%) were single women. A 2015 report for the country estimated that 24% of Peruvian adults of reproductive age (18-49) were married while 29% were cohabiting (Child Trends, 2015). Thus eliminating the households in which the heads of house were outside the reproductive age, the percent of married heads of house who have adopted the filters rose to 77.8%, which is much greater than the national average of 24%. In addition, it appears that generally older heads of house adopted the SAWYER water filter. This is

important because Peru is a young country, with the median age being 27.3 years old and only 14.48% of population is over 55 (Cental Intelligence Agency, 2015).

4.2.4 Urban and Rural

In Peru, communities within a district are referred to as "centro poblados," (CPs) meaning population centers in English. An urban CP is defined as an area that has at least 100 homes grouped contiguously, forming blocks and streets. An urban area is defined as territory within a district that is comprised of urban CPs. The only exception are district capitals, which are considered urban areas whether or not they meet this condition. A rural CP is therefore defined as an area that does not have 100 contiguous homes, is not a district capital, and if it has over 100 homes, they are dispersed or scattered without forming blocks or a nucleus.

According to the World Bank (World Bank, 2015), 79% of Peru's population resided within urban areas. In this study, 87% of households surveyed were considered within an urban area. The exact test did not find the proportion of urban households (87%) in this study to be significantly different from the national percentage of 79%, $p = 0.552$, thus showing the sample size is representative of the national figure.

4.2.5 Television, Cable, Computer and Internet

The household survey also included questions about access to television with cable, Internet, and the possession of a computer. The number of color televisions per household and Internet type in houses were also collected as data. These commodities not only allow for greater access to mass media, but are indicative of higher social standing in a location where most people do not currently own them. The second column of Table 4-4 shows the percentage of households in the region of Ica that have a television with cable, a computer, and Internet within the home. The households surveyed have much greater access to cable television and computers with Internet than the national average. Additionally,

100% of the households surveyed had access to television with cable, and 13 of 15 houses (87%), had two or more color televisions within the home. The remaining two households had one color television.

In the Ica region 38% of households in the Ica region had at least one computer while 13 of the 15 (87%) surveyed have a computer in the home. The exact test indicates a significant difference in the proportion of households with a computer in the study's sample (87%) as compared to the value of 38% that was obtained on a regional scale, $p = 0.001$.

Over the last several years, access to the Internet has grown steadily throughout all of Peru. In the region of Ica, Internet access within the home was at 10% in 2010 and rose steadily to 25.2% in 2014. Of the households surveyed, 13 out of 15 (87%) had an Internet connection within the home, more than triple the average for the region of Ica. The exact test also indicated a significant difference in the proportion of households with internet in the study's sample (87%) as compared to the value of 25.2% obtained on the regional scale, $p = 0.001$. Five of these households (33%) even had WiFi connections within the home, uncommon in the region based on the author's experience.

Table 4-4. Percentage of households with access to television with cable, computer, and Internet in the Region of Ica as compared to the households in the study.

	Percentage of households in Ica	**Percentage of households in this study**
Television with cable	35.5	100
Computer	38.1	86.7
Internet	25.5	87

Based on the results in this section, it was determined that the hypothesis that the households included in the study have a higher overall socio-economic status could be supported. Although the statistical analysis of the PPI® scores could support or reject the hypothesis, the results from question number five of the PPI® did show that the percentage of houses that were part of the survey with walls made of noble material was statistically different than the national average. In general, households had

more married heads of house than the national figures, household heads are more educated, especially the women, and access to cable television and computers with internet was much higher than regional figures. Also worth noting, 4 of the 15 households, 27%, had their own businesses as the family's main source of income, while 4 of the 15 households, 27%, had a least one head of house working as a civil servant.

4.3 WASH Related Habits and Characteristics of SAWYER Water Filter Users

4.3.1 Water Access and Water Storage

In the region of Ica, 73% of households have a water connection within the home (Instituto Nacional de Estadística e Informática, 2013). Of the households surveyed for this study, 100% of them where connected to the municipal water supply. Of the 15 households, 14 had a water connection within the home (93%) and one household had a water connection outside the home in a wash area. The exact test indicates no significant difference in the proportion of households with households in the study's sample with a water connection within the home (93%) as compared to the value of 73% obtained on the regional scale, $p = 0.086$.

However, having a water connection within the home does not mean having access to running water at all times; in most areas of Peru, water service is intermittent (Carreazo et al., 2006). Having running water within the home typically means having an elevated roof tank for water storage. In some cases, houses also have an underground storage tank that is connected to the elevated roof tank. It is worth nothing that high density polyethylene (HDPE) tanks, the tank type most frequently observed by the author in Peru, may compromise water quality. In a study of roof tanks in Bolivia, microbial contamination as measured by *E. Coli* was found to be higher in HDPE tanks possibly due to the black color of the tank increasing the temperatures and promoting bacterial growth (Schafer, 2010; Schafer and Mihelcic, 2012).

Of the households surveyed, three had an underground storage tank and 12 of the 15 had elevated tanks on the roof to provide running water throughout the home 24 hours a day. Three of the 13 households with a roof tank had more than one. The only household without a water connection within the home used a slightly elevated roof tank to store water in the wash area, but does not use the tank to provide running water throughout the home. This means that two of the households have running water within the home during service hours, 12 houses have running water 24 hours a day, and one house with the outdoor tank only has running water in an outdoor wash area.

No national statistics exist on the percentage of houses with elevated roof tanks and underground water storage. A study in neighboring Bolivia found that in a small agricultural community of 66 households, only 22% of households surveyed had the HDPE tanks that are the most commonly used in coastal Peru (Omisca, 2011). Through the thesis author's experience living and working in Peru, she observed that water tanks were generally associated with higher socio-economic status and were not prevalent outside of cities. The household with the lowest PPI® score (58) has an Eternit (a popular brand of HDPE tanks), but it is not on a roof or connected to indoor plumbing. This is possibly due to the fact that an elevated storage tank requires a roof that is made of noble materials or a separate support structure, which that house did not have. The household surveyed with the second to lowest PPI® score (64) also did not have a roof storage tank. Although it cannot be established that SAWYER water filter users have greater access to running water and higher quantities of water than non-users, users have HDPE tanks at a much higher percentage (80%) than in the Bolivia study (22%). Through this and through the author's observations in Peru, it can be suggested that SAWYER water filter users generally have more access to running water at all hours of the day than non-SAWYER water filter adopters. Durabio could seek to form partnerships with manufacturers or distributors of elevated roof tanks to promote the filters as part of a household water improvement system. On the website or in publicity, they could

also advertise the filter's ability to improve water quality which can drop through the use of HDPEs for water storage.

4.3.2 Sanitation Facility

The INEI does not specify what type of toilet a household has but rather how their excreta is managed. It can be assumed that a household connected to the sewer has a fully functioning flush toilet or a pour flush toilet. The INEI reports that 63.5% of residences in Peru have a sewer connection within the home. For the urban areas, the percentage rises to 79% and for rural areas the percentage of residences with sewer access falls to 15%. In all of Peru, 10.1% of households are connected to a septic tank, while 26.4% rely on another method such as latrines, have no excreta management, or use the river or irrigation canal. In rural areas, the lack of an excreta management systems in households is 22%. Of the 15 households surveyed, 13 (87%) were connected to the public sewer systems inside the home, while the one of the homes had a septic tanks, and the final home had an unspecified, independent excreta management system. Even then, the exact goodness-of-fit test indicates no significant difference in the proportions study's sample excreta management types as compared to national proportions $p = 0.181$.

All the houses had toilets that functioned through flushing, but the three houses without regular running water had to manually flush when the municipal water service was limited. Even though the exact test did not reveal a significant difference in sewer connection type of households that utilize SAWYER water filters and the national percentage, by comparing the study findings with the national statistics, it appears that SAWYER water filter users generally have more access to sanitation facilities than non-adopters, especially knowing that all homes had toilets with flushing capability.

4.3.3 Handwashing

Unlike the previous themes assessed on a household level, the data on handwashing was collected in the surveys of individuals. A report published in 2004 by the Environmental Health Project

(EHP) (EHP, 2004) and a technical paper published in 2010 by the Water and Sanitation Program (WSP) (Galiani et al., 2012) served as the national basis for comparison on handwashing. The 2004 report was the first step in a national campaign to reduce diarrheal diseases in children and was meant to set the baseline that would serve as guidelines for the design of the promotional campaign. The 2010 report served as the baseline for an evaluation of the Global Scaling Up Handwashing Project. The 2004 report included data from 2,959 hours of observation, while the 2010 report relied on self-reporting and observation of sanitation facilities. Because there is usually a discrepancy between self-reported and observed behavior, the results of both reports are discussed and compared to this study's findings.

4.3.3.1 Handwashing Facility and Use of Soap

In Peru, handwashing stations are typically a sink with a tap or faucet (48%) or a plastic basin or bucket with water (49%) (Galiani and Orsola-Vidal, 2010). In the EHP report, 811 (40%) out of 2037 observations of handwashing were with running water from a faucet or hose, 700 (34%) were of handwashing in a recipient with stagnant water, 470 (23%) were of a pitcher being used to produce running water, and the remainder were of handwashing with river, irrigation canal, or another water source (EPH, 2004), similar to the WSP findings. Of the 39 participants surveyed in this study, 18 (46%) reported they washed their hands in a sink. Thirteen (13%) survey participants specifically mentioned both kitchen sink and bathroom, one teenager mentioned handwashing at the school, 6 (15%) said only bathroom sink, and one person (3%) mentioned washing hands in a clothes washing area. Two mentioned having to use plastic containers on some occasions for handwashing. One of them was a professor who taught at a school that had no running water. The other was a SAWYER water filter user who lived in the same building as the family who possessed the SAWYER water filter, but her unit did not have running water. Even then, all home have a tap or faucet that has running water at some point during the day, which is over double the national percentage reported in the WSP study. The WSP also found that the higher the income, the closer the handwashing station was to the toilet or kitchen. In the

households with highest income, 38% of handwashing stations were inside the kitchen or toilet facilities. In the coastal areas, in which this study site is located, 50% of handwashing stations were reported to be located inside the kitchen or toilet facility and 67% of the households surveyed on the coast had handwashing stations with soap and water. In the region of Ica, it was between 50-60% (Galiani and Orsola-Vidal, 2010). In this study on SAWYER filter adoption, all of the households had a toilet, shower, and sink in their bathroom, but in two of the homes the shower and sink were not hooked up to running water, while another two only have running water in their bathrooms when the municipal supply is on. Findings show that generally SAWYER water filter users have access to handwashing facilities with running water in the bathroom or kitchen or can produce running water from a pitcher at a handwashing station at higher rates than national studies have found.

In the WSP study, all caregivers reported to wash hands with soap and water at least once in the previous 24 hours, but only 64% of households had a handwashing station with soap and water. Handwashing stations with soap and water was much higher in the wealthier households. In the EHS study six years before, all houses were found to have some type of soap, mostly detergent, and more than half had running water, yet still handwashing was not prevalent. The WSP observed that 42.7% of households surveyed had powder soap or detergent followed by 30.6% with toilet bar soap.

In this study, the presence of soap at handwashing stations was not observed. Instead, the participants were asked if they used soap “always, sometimes, or never.” Of the 39 participants, 67% said they always used soap and 30% said they used soap sometimes. Seven people (18%) specifically mentioned using liquid soap, which was never mentioned or observed in the EHP of WSP report. It is possible that liquid soap is a product that implies a higher status in a location where most people use powder soap. The author did not observe much use of liquid soap in Peru, possibly because of its higher cost and lower availability.

The EHP found that 29% of people observed washed their hands after an event of contact with feces, and soap was only used 14% of the time and 20% of people washed their hands before handling food, while 6% of them used soap. Overall, Peru has low rates of soap use when handwashing. Although self-reports are typically higher than observed rates, 18 (46%) said "with soap," 16 (41%) responded "with soap and water" when asked "how do you wash your hands?" Only 2 out of 39 (5%) replied "with water." Generally, SAWYER water filter users know they should use soap when they wash their hands, and 66.7% report to always use soap.

4.3.3.2 Knowledge of Critical Handwashing Moments

During the personal interview portion of the surveys, SAWYER filter water users were asked the open-ended questions "At what moments do you wash your hands?" and "How do you wash your hands?" As Figure 4-1 shows, twenty-five people (64.1%) specifically mentioned they washed their hands after going to the bathroom, 17 (43.6%) mentioned before cooking, and 15 (38.5%) mentioned before eating. Another common response was making a general statement such as "at all times," "constantly," or "morning, noon and night" (38.5%).

Figure 4-1 shows that a higher percentage of SAWYER water filter users responded "after using the bathroom" than in in the Global Scaling up Handwashing Project baseline survey, in which researchers asked caregivers to mention under what circumstances they used soap to wash their hands in the last 24 hours (Galiani and Orsola-Vidal, 2010). In the baseline survey, 46% mentioned handwashing after using the toilet, while 64.1% of SAWYER water filter users mentioned it. On the contrary, SAWYER water filter users responded "before cooking" (46.3%) at a lower rate than the baseline survey (68.3%), but still at a higher rather than they responded before eating (38.5%). It is possible that the participants of the WSP baseline study answered "before cooking" at a higher rate because they were in all caregivers. According to SAWYER water filter users' responses, they place more

importance on handwashing after potential fecal contact when using the bathroom than with food preparation and consumption.

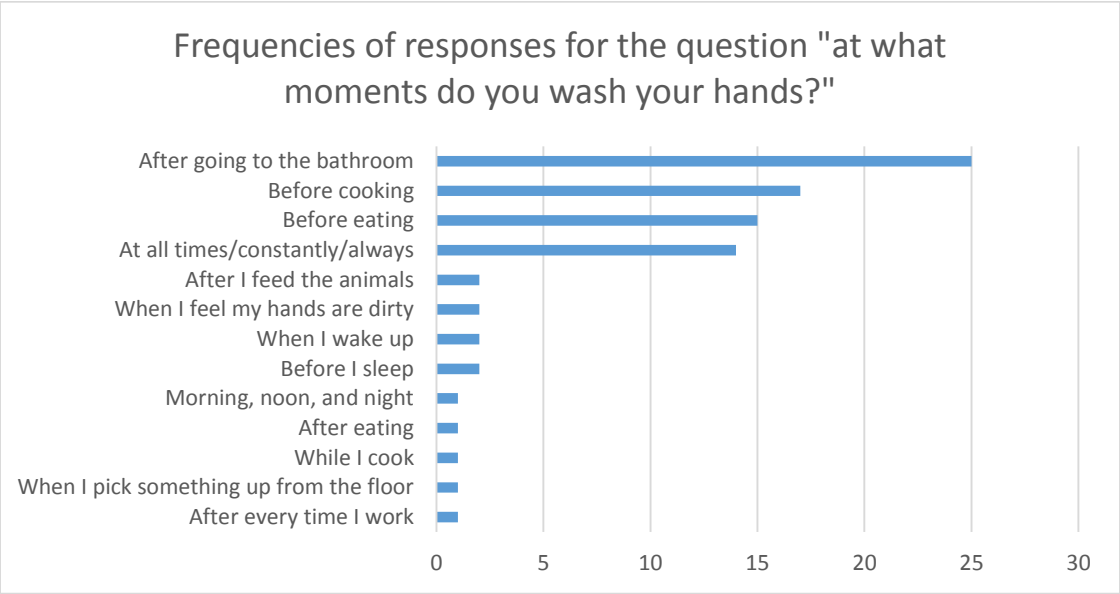

Figure 4-1. Frequencies of responses for the open-ended question "at what moments do you wash your hands?"

When asked “how do you wash your hands?” 18 (46%) said “with soap,” 16 (41%) responded with soap and water, 5 (13%) imitated a hand scrubbing motion. Most people mentioned soap, implying that SAWYER water filter users understand the importance of soap for handwashing. This is in contrast to the 2004 study in which the mothers surveyed reported it was only necessary to use soap when dirt is evident (EHP 2004). Responses to the question also varied from one word answers to detailed explanations, particularly with several participants who considered handwashing important to their profession. One SAWYER water filter user was a chef at the hotel where he lived and worked. He reported to wash his hands “every fifteen minutes. That is what my job demands of me” and said that when he washes his hands, it is “from the tip of my fingers to my elbow. Disinfectant soap and afterwards, liquid alcohol” (assumed to be hand sanitizer.) One SAWYER water filter user described

herself as “fussy about handwashing” because when studied nursing “they taught me about handwashing and due to that, I have soap everywhere.”

4.4 Health Belief Model

The following sections present the results of the Health Belief Model open-ended questions and written Likert scale surveys. In each section, SAWYER water filter users’ perceptions and motivations are interpreted by assessing their survey responses in the local context with the help the author’s experience and the conversations had during the interviews. This section also presents recommendations based the results that can be useful in designing promotional strategies for the SAWYER water filter.

4.4.1 Perceived Severity of Diarrheal Diseases

Figure 4-2 shows the response frequencies of SAWYER water filter users for the Health Belief Model statements related to the perceived severity of diarrheal diseases. While administering the Likert scale surveys, some participants asked questions or made comments about the first statement “diarrhea is not a serious disease.” This statement was one of several that was recognized as being unclear or able to be interpreted in several ways. For those who agreed (44% strongly agree or agree), their perception can be interpreted in several ways: diarrhea is not a serious diseases because it can be treated or prevented, diarrhea is not a serious diseases because its effects are not serious, diarrhea is not a serious disease because affects so many people that it is a regular part of life, or that diarrhea affects so little people, that it is not perceived as serious. Through conversations with survey participants, it was concluded that for those who agreed with the statement, they seemed to believe that diarrhea is treatable/preventable or is just a regular part of life that has no serious consequences.

The group was also split on the statement “diarrheal diseases do not have severe economic consequences.” A little over half the group, 51%, disagreed or strongly disagreed with the statement, while 39% of those who responded either strongly agreed or agreed, demonstrating that although most

consider the expenditures related having diarrhea, a large portion of filter users do not consider it a "serious" consequence. Only 23% mentioned economic expenditures as a main consequence of diarrhea when asked the open ended question "what are some of the consequences of having or of your child having diarrhea?" One of the women who participated in the study worked in a house that had a filter and used the filter daily, but lived in a rural part of Independencia with no running water. She talked about the economic consequences of having a child with diarrhea, explaining "sometimes they don't have what you need at the health post so you have to buy it. Because I have SIS (insurance) but sometimes they don't have the medicine at the health post and I have to go out and buy it. That affects me."

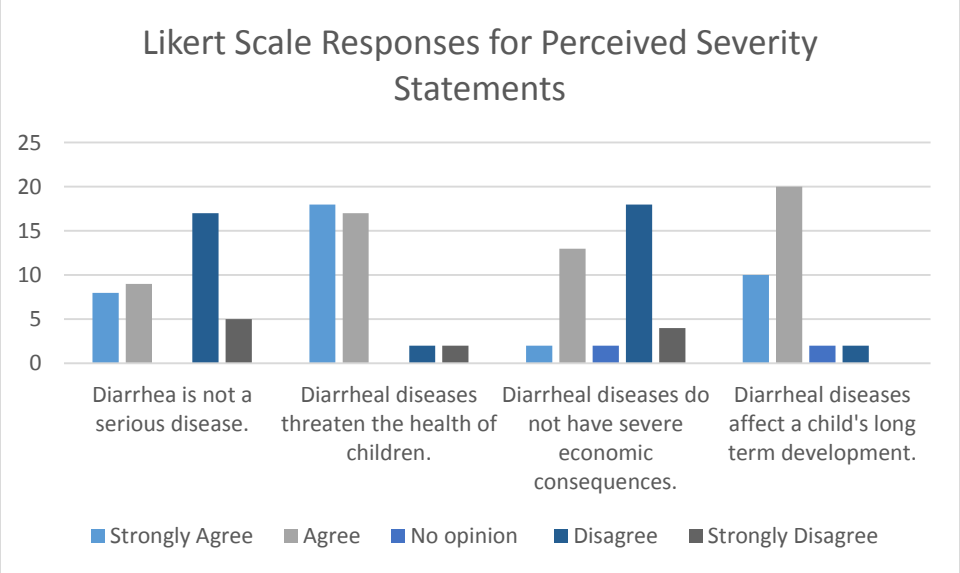

Figure 4-2. Frequencies of responses for perceived severity statements of the Health Belief Model survey.

In contrast to the questions about seriousness and economic consequences, the two questions that mentioned the children were greatly similar in the responses. Most filter users (90%) agree or strongly disagree that diarrhea threatens the health of children, while 88% agree or strongly agree that diarrhea affects a child's long term development. This could mean that adults may not perceive diarrhea

as serious for their age group, but acknowledge that it is a greater threat to children. Some adults may perceive diarrheal diseases as specific to children or may perceive that adult's bodies can handle diarrhea, while a child's system cannot. These results are similar to those from a study Panama that found children and severity/susceptibility to diarrheal disease to be often interrelated. Ten out of 52 women who participated in that study mentioned children being more susceptible to diarrheal diseases, making statements such as "If we do not take care of it, the children will have diseases." These results show that generally, people are aware and more concerned about diarrheal diseases affecting children than adults. Durabio campaigns should therefore promote the health of children to appeal to adults' sense of responsibility.

4.4.2 Perceived Susceptibility to Diarrheal Diseases

Figure 4-3 shows the frequencies of responses for the statements measuring perceived susceptibility to diarrheal diseases. The responses to the first two statements "Diarrheal diseases don't affect my life much" and "Diarrheal diseases cause my family or close friends difficulties" show that SAWYER water filter users recognize the pervasiveness of diarrheal diseases. Of the 39 people surveyed, 68% disagree or strongly disagree that diarrhea does not affect their lives while 79% of respondents agree that diarrheal diseases cause family of close friends difficulties. The third statement was one of several determined to be unclear through the process administering surveys. Some respondents said that they can be confident that they will not have diarrhea because they take their own precautions to prevent it. Even then, 32% believe that it is likely that they will have diarrhea soon, suggesting that many participants feel susceptible to diarrhea even with the use of the SAWYER water filter, which is possible due to the other routes of contamination such as food. Almost all of users (92%) believe that drinking "raw" water is dangerous. It is possible that those who disagreed believe that adults who have gotten accustomed to the water are not at risk or that they have bravado attitudes, typical of males, towards

raw water consumption. Overall, SAWYER water filter users do perceive themselves as susceptible to diarrheal diseases and they acknowledge that diarrhea is a common problem.

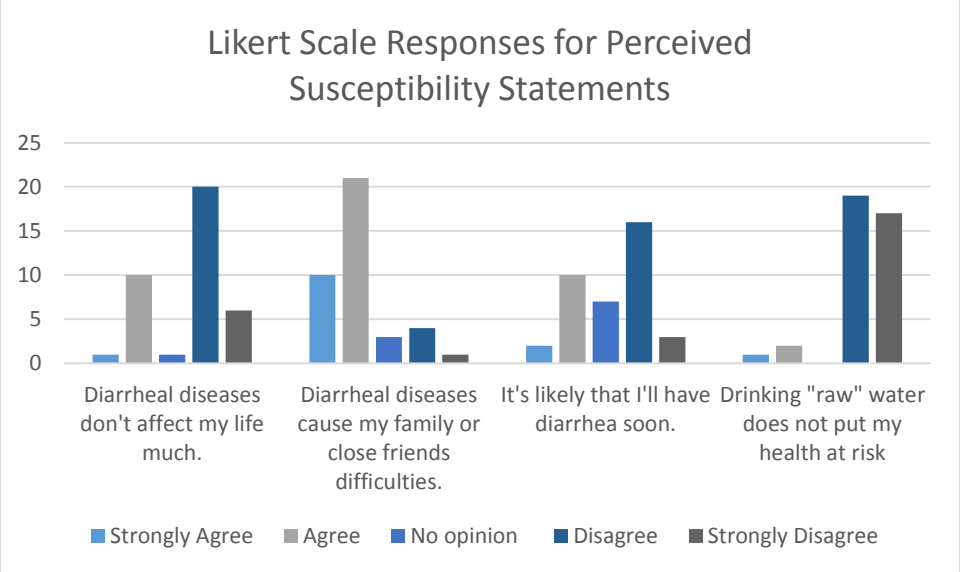

Figure 4-3. Frequencies of responses for perceived susceptibility statements of the Health Belief Model survey.

4.4.3 Perceived Benefits of the SAWYER Water Filter

Figure 4-4 shows that SAWYER water users were in greater agreement on the perceived benefits of the SAWYER water filter than on any of HBM model construct. Even though the statement “the health of my family is not affected by the use of the SAWYER water filter” was identified to be unclear or open to interpretation, those who disagreed with the statement mentioned how the water filter positively affects health. Some participants even report immediate and positive improvements in their health. When one filter user was asked about the benefits of the filter, he responded “the fact that when we all had horrible diarrhea and then it went away” after the family began to use it. The second statement can also be interpreted as “the health of my family is not negatively affected” or “because the family consistently treated water before, their health is not impacted by a different water treatment option.” Even though the second statement is unclear, the remaining three statements on perceived benefits had

clear results. Only one person disagreed that the filter could save them money in the long run, the same person who disagrees that the filter reduces the risk of diseases. Looking at the survey, it is unclear if their response was intentional or a misunderstanding, but either way almost all filter users perceive the filter as time and money saving, and as reducing the risk of diarrheal disease. SAWYER water filter users seem to be very confident about the benefits of the product. When answering the open ended question "what benefits did you see in the filter that lead you to use it?" the most common answers to avoid boiling (31%) and the improvement of water quality (36%). Comparing the SAWYER filter to other methods, one user described is as "faster when you filter the water. You can drink it straight up without having to boil it or having to let it settle. It's like, more natural." Another participant focused on the economic benefits of filter, "We save even, from boiling the water, the gas. We save economically apart from the benefits that they don't get sick so much, most of all with parasites."

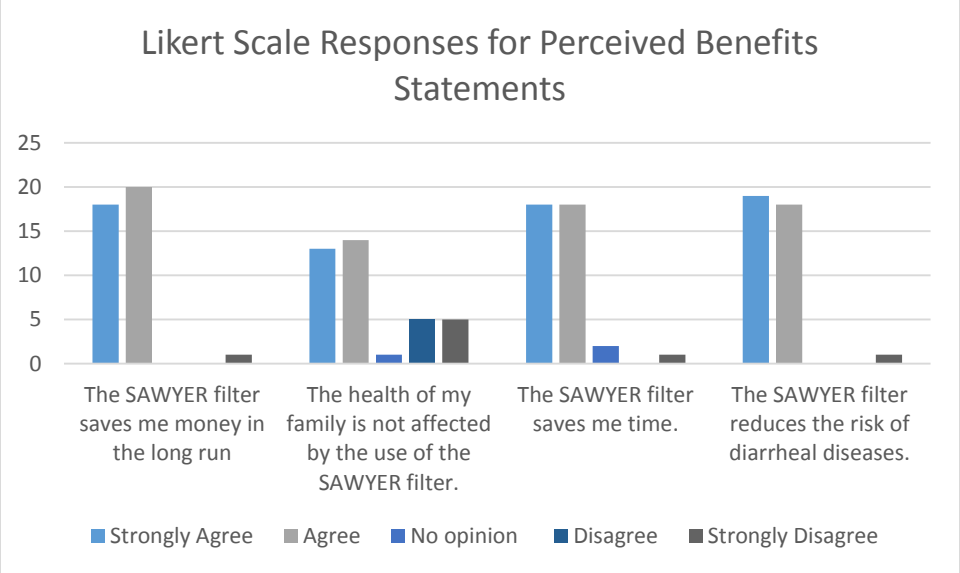

Figure 4-4. Frequencies of responses for perceived benefits statements of the Health Belief Model survey.

4.4.4 Perceived Barriers to Adopting a SAWYER Water Filter

Figure 4-5 shows that respondents were in much less agreement over the barriers to adopting a SAWYER water filter than the benefits. Many had no opinion for the first two statements "The price of the SAWYER filter is high" and "The availability of the SAWYER filter is low" possibly because they were not the ones who purchased the filters so they unaware of how the filter was obtained. Most people disagree that the cost of the filter is high (56%) even though only 3 out of 15 households paid for their SAWYER water filter in one payment, indicating that the product is something that requires users to save money to purchase. Two SAWYER water filter users specifically mentioned the cost of the filter in comparison to others as their main reason for buying it. One user explained that "other filters exist, but they're too expensive. And they only last for a certain time. It was a larger investment for less time. On the contrary, this filter is more economical." The other agreed, stating that "I was worried about the water quality and all (the other options) were above my purchase capacity." When describing other types of filtration methods, the same user described "reverse osmosis but it's too expensive. There are also other filters - ionized carbon, ionized silver, etc. but they are all expensive and difficult to maintain. You have to buy replacements and they have to be maintained by a person trained for that." Still, for some the cost of the filter is too high. Three of the households surveyed borrow the filter, but do not have their own and would like one, but consider the cost too high. One user, a domestic helper in one of the houses, talked about needing a filter because her water comes directly from the irrigation canal, but it is not a possibility because she cannot afford it.

The answers to the last two statements "I don't like having to adapt to a new technology" and "I don't trust an unknown technology" are somewhat contradictory. While most people (74%) do not mind adapting to new technologies, 36% of participants say they do not trust unknown or unfamiliar technologies. Because there is an overlap, some of those who do not mind adapting to new technologies are still distrustful of them, meaning that those people are more comfortable adopting a new

technology once they are more familiar or see other people using is (one case in Section 4.4.6 discusses a situation like this). Overall, with these results it is difficult to establish what SAWYER water filter users perceive to be the main barrier to adoption. When participants were asked about having any doubts about the filter, 51% answered no, while 30% did not think the filter would work. Of those who believed the filter would not work, some doubted the filter's efficacy, the legitimacy of the SAWYER guarantee, or the word of a relative who recommended it.

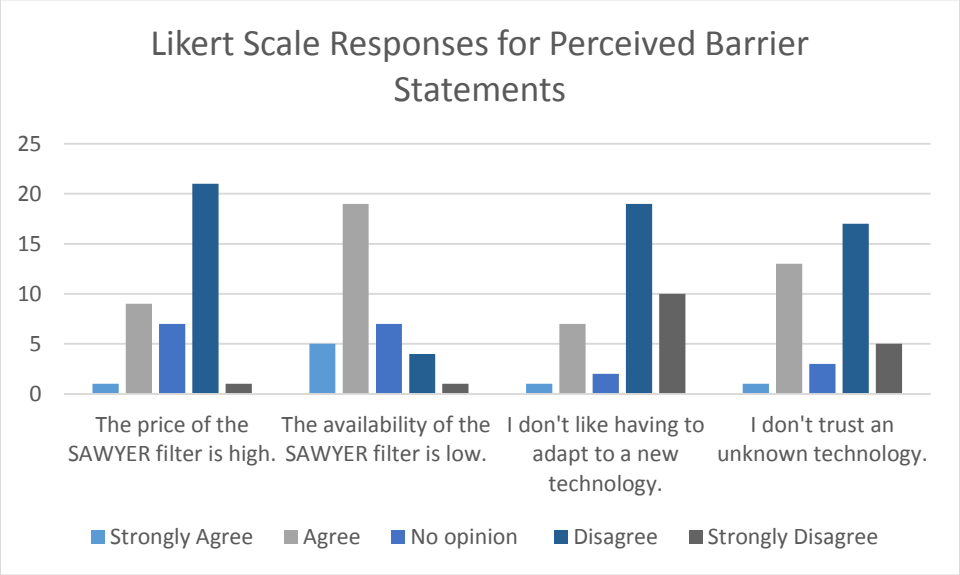

Figure 4-5. Frequencies of responses for perceived barrier statements of the Health Belief Model survey.

4.4.5 Cues to Action

The results of the Cues to Action statements, represented in Figure 4-6, show several situations that can motivate a person to adopt the SAWYER water filter as a water treatment technology. Most of the participants (64%) strongly agreed or agreed that they or a family member has suffered from a water related illness. Although fewer responded agreed to this statement than 79% who agree that diarrheal diseases cause family of close friends difficulties, these results show that most SAWYER water filter users have been affected by diarrheal diseases or water related illnesses. Most of the SAWYER

water filter users (89%) were recommended the product by a friend of family member and 79% saw some sort of demonstration, either by a family member, other user, or Durabio, before using the product themselves. These results show the importance of this type of face to face contact and interpersonal communications. When asked "was there an action, sign, or experience that led you to try the filter?" seven users (18%) specifically mentioned a demonstration by a family member and six users (15%) mentioned demonstrations at a Durabio presentation.

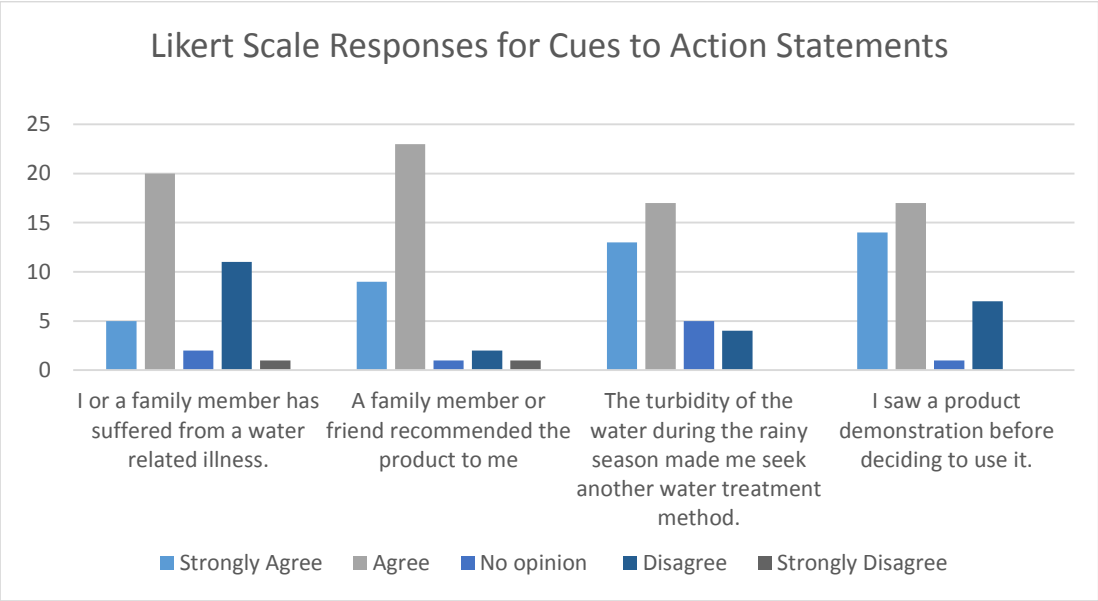

Figure 4-6. Frequencies of responses for cues to action statements of the Health Belief Model survey.

For many of the users, seeing the SAWYER water filter was a critical part of their decision to try it out. One user describes the impact of seeing the filter clarify turbid water: "what strikes you the most is that water that is completely turbid, full of dirt and sediments, passes through the filter, the first impression that one gets is that the water becomes completely transparent. That's one of the first things that impressed me the most." The water's turbidity during the rainy season in the mountains also presents problems for many on the coast. The water must settle first in storage tanks to be able to be used for cooking or washing clothes. One user specifically mentioned using the SAWYER water filter to

clear up the water before doing laundry. Some users purchase alum to speed the setting or use penka, a natural coagulant from the Tuna cactus plant. Most users (77%) agree that the yearly spike in the water's turbidity lead them to seek out another water treatment alternative. A study on water consumption in Panama found that mothers take different preventative measures during the different seasons. One mother stated that "when is winter is not safe, because it rains a lot and drag in trash. (Vega, 2013)" This is similar to coastal Peru where the rain in the mountains drags contaminants and sediments into the river, forcing many coastal residents to alter their water consumption habits. Durabio can capitalize on these cues to action by targeting regions where the water quality drops during the rainy season in the mountain, by coming up with promotional strategies that encourage customers to advertise to friends and family such as rebates for users who recommend new customers or family discounts, and by placing more importance on personal interactions with potential customers.

4.4.6 Self-efficacy of SAWYER Water Filter Users

The statements in Figure 4-7 were used to measure SAWYER water filter user's perceptions about their own ability to succeed or accomplish tasks. The first statement asks assesses how many users had doubts when using the filter initially. How can self-efficacy be related to overcoming doubt over a product? Someone with low self-efficacy may not be able to overcome the doubt and try something new for themselves. For example, one filter user discussed the influence her husband had on her decision to try the filter. When asked the open question "Did you have any doubts about using the filter," she replied "Yes. I thought it did nothing. That's why I didn't drink the water." The study author asked "why did you change?" and she responded "because he drank it and nothing would happen to him. I would take the water and I would boil it, but then I saw that he wouldn't get sick, I started to drink it." On the contrary, a person's response to doubting the filter can show high self-efficacy. One user responded "At first yet, because it's hard to believe that such a small apparatus can purify water like it does, but then I looked up it up on the Internet and tested it out myself and now I have no doubts with

respect to its quality." Some users with doubts were able to overcome them through the influence of others, while some took it upon themselves to do research and verify the filter's performance themselves.

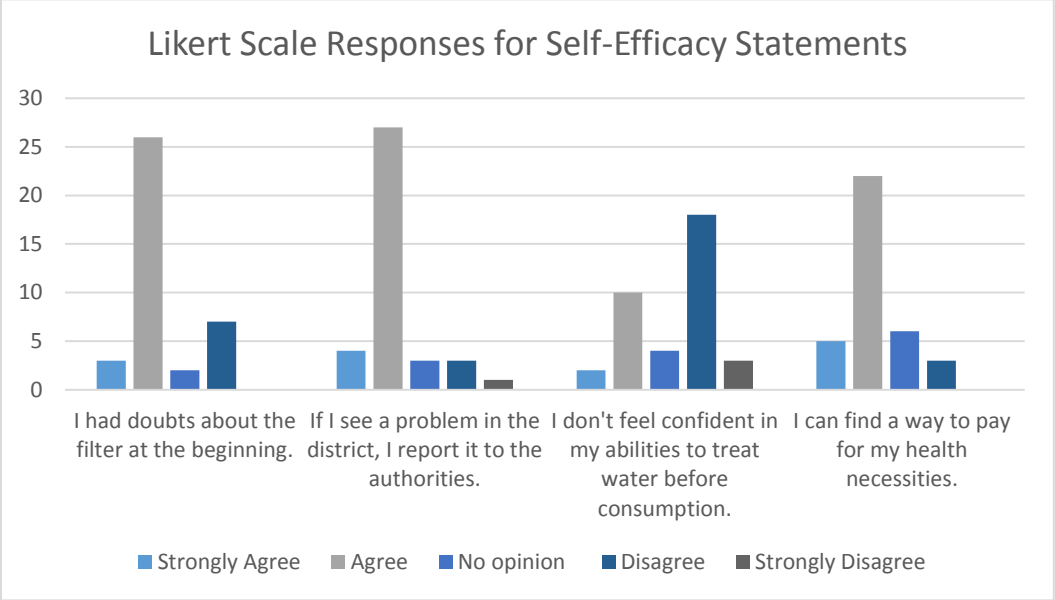

Figure 4-7. Frequencies of responses for self-efficacy statements of the Health Belief Model survey.

Of the 39 people surveyed, 82% of participants reported to inform authorities when there were problems in the district, although many commented that "it's pointless because the authorities do not respond." Some people also stated this as the reason they do not report issues in the district. Statement number three was identified to be unclear. Many were unsure as to whether or not this question meant before acquiring the filter or after. Still, most people (57%) disagreed that were not confident in their abilities to treat water before consuming it. The results of question four revealed more about SAWYER water filter users' perceived self-efficacy. Most users (75%) agreed or strongly agreed that they would be able to find a way to pay for health related expenses. These results seemed high based on the researcher's observations and life in Peru in which she observed on many occasions families unable to pay for medical expenses. One person who disagreed stated that sometimes paying for medical

expenses was just not possible, which shows that those who responded that they could find a way to pay for health necessities are self-assured and confident in their abilities.

CHAPTER 5: CONCLUSIONS

5.1 Summary of Findings

In this research, a mixed methods approach was used to gain a better understanding of SAWYER water filters with respect to the three themes of socio-economics, WASH, and the HBM. Under each theme, several factors were quantified and assessed to reach a conclusion. Some of the factors were more valuable than others for reaching conclusions about the three themes studies.

With the results of the PPI®, the socio-economic status of SAWYER water filters users could not be determined with certainty. Even then, all households that adopted the filter were found to have less than a 10% chance of being under the poverty line. Other indicators of socio-economic status of filter adopters were more revealing; material of exterior walls, having a computer in the home, and Internet in the home were all statistically different from the national or regional averages. SAWYER water filter users were also found to have access to internet, cable, and computers at higher rates than the region which not only indicates greater wealth among filter users, but also the tendency to adopt technologies early on. Although SAWYER water filter users were found to have greater access to mass media through cable TV and computers with internet, interpersonal communications are thought to be more important as shown in the results of the HBM survey.

Although both men and women who had adopted the filters were more educated on average than the national percentages, the women in the study were statistically different form the national average. Not only did female adopters achieve university or post-graduate degrees at three times the national rate, but five of thirteen women with partners were more educated than the man. One study, Freeman et al., (2012) also found a significant difference in education levels between adopters and non-adopters of a filter, while several studied showed that higher level of education of women is significantly

associated with higher rates of handwashing (Luby et al., 2009; Schmidt et al., 2009), while a father's education level was not found to be significant (Luby et al., 2009). The female heads of house were generally more educated than the men, suggesting that the women could be the ones pushing families to adopt filter use. Heads of household of SAWYER filters were also married at a higher percentage than the national average which indicates more structured family units for these households based on the percentages and on the study author's observations living in Peru, also indicative of higher socio-economic status.

The rates of water connection within the home and connection to sewer in this study's survey sample were not different from the national numbers, indicating that SAWYER water filter users to not have greater access to water and sanitation facilities than the general population. Although the self-reported handwashing habits in this study did not indicate major differences from the general population based on two previous studies (Galiani and Orsola-Vidal, 2010) (EPH, 2004), all households had a tap or faucet that had running water for at least part of day. Most people (67%) claimed to use soap every time they washed their hands and seven people specifically mentioned liquid soap which could be more of an indicator of socio-economic status than actual hand hygiene habits. Overall, the inferential statistics and qualitative analysis do not support the hypothesis that SAWYER water filter users have more access to water and sanitation and better handwashing habits than the general population, but over they do have good access and high self-reported rates.

The results of the HBM survey revealed several key factors. Participants had the highest degree of agreement when asked about the perceived benefits of the filter. Improved water quality, saving money in the long run, and saving time were all key benefits that let to adoption, but no obvious barrier to adoption was identified. Unlike other studies in which the high cost of treatment is cited as the main barrier (Luby et al., 2008), 56% of participants disagreed that the cost of the filter was high. The low availability of SAWYER water filters seemed to be the clearest barrier. The HBM statements on

perceived severity revealed that adults generally considered diarrheal diseases more severe for children than for themselves, while the perceived susceptibility statements showed that almost all adults believe drinking untreated water puts their health at risk.

The other HBM construct with high agreement in this study was cues to action. Almost all SAWYER water filter users (89%) were recommended the product by a family or friend and 79% of users saw some sort of demonstration before deciding to use the filter, similar to SODIS in which those had had repeatedly participated in promotional events were found more likely to use it (Christen et al., 2011). Also, 77% of the SAWYER water filter users surveyed agree that the yearly spike in turbidity led to adoption indicating that seasonality plays a role in filter adoption, similar to a previous study in which users only treated the water during the rainy season (Wood et al., 2012). Even though SAWYER filter users were found to have high self-efficacy (75% of users are confident they can find a way to pay for medical expenses,) the perceived benefits and cues to action were the two HBM constructs that seemed to affect SAWYER water filter users' decision to adopt the technology the most, thus rejecting the hypothesis.

The household survey revealed that many SAWYER water filter users were business owners. Perhaps business owners are more open to adopting new technologies because they are more exposed to outside ideas, they cannot afford to have sick days, or they are accustomed to thinking for themselves and having to try to new things for the benefit business. One of the SAWYER water filter users purchased a filter to benefit his small restaurant. He was spending money on bottled water during the season of high turbidity and decided to try out the SAWYER water filter as a money-saving alternative. Perhaps SAWYER water filter users are by nature more entrepreneurial, more willing to adopt new technologies, and greater risk-takers than the general population.

5.2 Limitations

The greatest limitation in this study is the lack of a control group. The study did not collect data from nonusers to serve as a comparison population. This study focuses only on SAWYER water filter adopters, studying their beliefs, behaviors, socio-economic characteristics, and access to WASH, leading to a greater understanding of the culture of early filter adopters.

The other principal limitation is the small size of the study sample. Only 15 households were surveyed, but that reflects the reality of how few SAWYER water filter users there are in the area. One house that was identified as having a filter did not participate in the study. Another filter was being used at the mining operation of one of the households, but the author could not make it to the mine due to its difficult access. Also, in three households, only one person was interviewed, potentially affecting any results that were based on individual responses. Because of the small sample size, the exact test was used for goodness-of-fit analysis. Even though the exact test accounts for the small sample size, a larger sample would provide more accurate results

5.3 Recommendations

The results of this study can help Durabio in the design of their marketing strategies. Durabio aims to reach the neediest persons in Peru to improve their quality of life, but the study shows that people buying the filter are generally of higher socio-economic status with a decent quality of life. To reach the neediest populations, Durabio can seek partnerships with the Peruvian government, be it national, regional, or by district, to provide government subsidies for this treatment technology, particularly in rural areas where the product's price is prohibitively high. For the middle class target audience, family discounts, rebates for recommending the product, or discounts for sharing about the product on social media could be an effective way of promoting the product using interpersonal communication between Peruvians themselves.

Future research is needed on the SAWYER water filter in Peru to understand the long term impact of using the product. Testing the filter's effectiveness after use in the field could provide insight into how the membrane responds to the contaminants specific to the region and to determine if SAWYER's lifetime claim holds up in the field. Also, studying customer satisfaction can provide an understanding of how to improve the product for more effective use in the field.

Several SAWYER water filter users mentioned that after the water passes through the filter, the water does not form a white precipitate when boiled. The white film, residue of hardness and other minerals, observed by the author in her own water boiler, is a nuisance to deal with and many people are concerned over potential health effects. A study on water hardness and the use of the SAWYER water filter would allow for a better understanding of how the filter removes hardness and how it affects the filter membrane efficacy.

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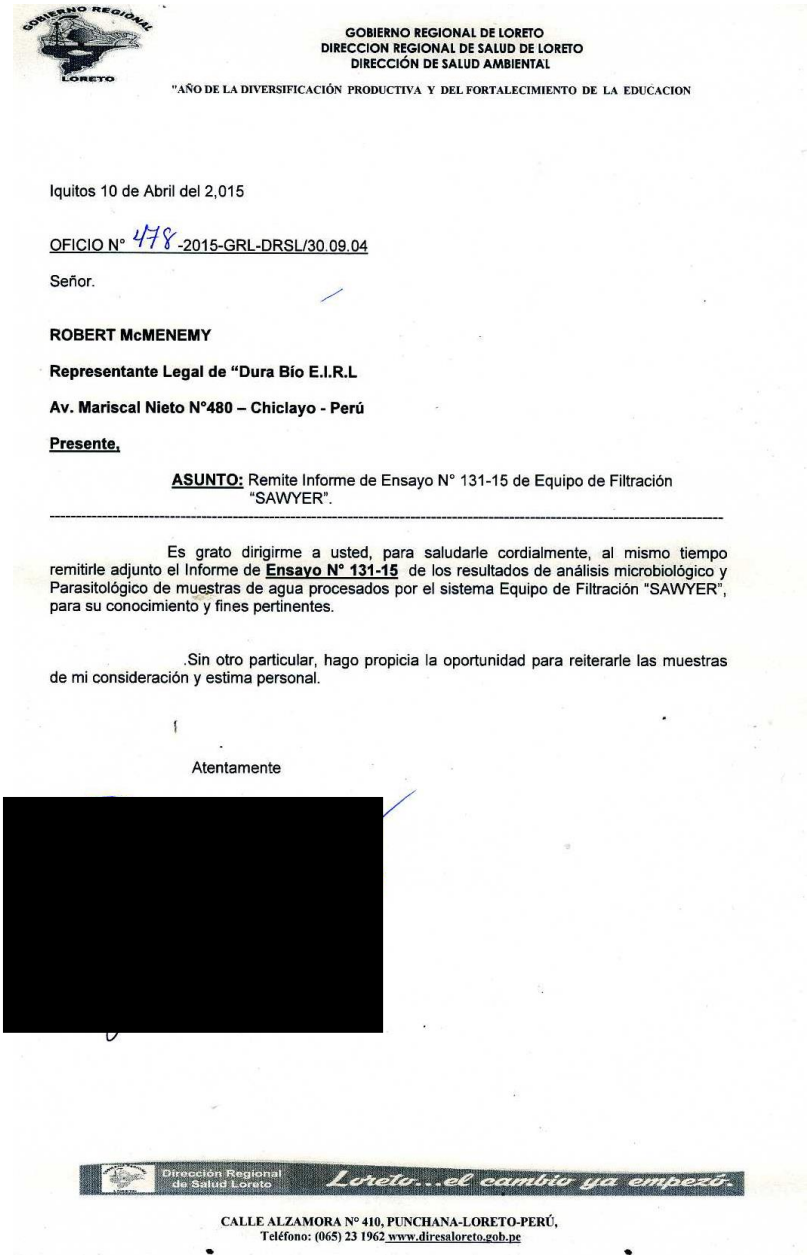
APPENDIX A: SAWYER POINTONE WATER FILTER TEST RESULTS FROM THE REGIONAL GOVERNMENT OF LORETO



GOBIERNO REGIONAL DE LORETO
DIRECCION REGIONAL DE SALUD DE LORETO
DIRECCIÓN DE SALUD AMBIENTAL

"AÑO DE LA DIVERSIFICACIÓN PRODUCTIVA Y DEL FORTALECIMIENTO DE LA EDUCACION

Iquitos 10 de Abril del 2,015

OFICIO N° 478 -2015-GRL-DRSL/30.09.04

Señor.

ROBERT McMENEMY

Representante Legal de "Dura Bío E.I.R.L

Av. Mariscal Nieto N°480 – Chiclayo - Perú

Presente,

ASUNTO: Remite Informe de Ensayo N° 131-15 de Equipo de Filtración "SAWYER".

Es grato dirigirme a usted, para saludarle cordialmente, al mismo tiempo remitirle adjunto el Informe de **Ensayo N° 131-15** de los resultados de análisis microbiológico y Parasitológico de muestras de agua procesados por el sistema Equipo de Filtración "SAWYER", para su conocimiento y fines pertinentes.

.Sin otro particular, hago propicia la oportunidad para reiterarle las muestras de mi consideración y estima personal.

Atentamente

[redacted]

Dirección Regional de Salud Loreto — Loreto...el cambio ya empezó.

CALLE ALZAMORA N° 410, PUNCHANA-LORETO-PERÚ,
Teléfono: (065) 23 1962 www.diresaloreto.gob.pe

Figure A.1. Test results from the regional government of Loreto showing an analysis of surface water from the Morona Cocha Lake before and after passing through a SAWYER PointONE water filter.

DIRECCION DE SALUD AMBIENTAL
UNIDAD LABORATORIO DE SALUD AMBIENTAL
INFORME DE ENSAYO Nº 131-15

I SOLICITANTE: **Sr. Robert McMENEMY**

Fecha/ hora de Muestreo	:	31/03/15	09:52 a.m.
Fecha/ hora Recepción.	:	31/03/15	10:30 a.m
Fecha/ hora de Análisis	:	31/03/15	10:50 a.m.
Fecha/ hora entrega Resultados	:	03/04/15	06:30 p.m.

II MUESTREO:

Por personal técnico de la Dirección de Salud Ambiental - Dirección Regional de Salud Loreto, en Av. Del Ejercito/ San José, Lago de Morona Cocha – Distrito Iquitos.

III DATOS DE LAS MUESTRAS:

* **H236-15** Agua superficial Lago Morona Cocha, a 10 mts. de la orilla.
* **C237-15** Agua superficial Lago Morona Cocha, a 10 mts. de la orilla procesado por el sistema Equipo de Filtración SAWYER. - Color ligeramente amarillento.

IV REPORTE DE RESULTADOS:

Nº	ENSAYOS	RESULTADOS		REQUISITOS		
		H236-15	C237-15	Agua Superficial A1	Agua Superficial A2	Agua Potable
01	Recuento de Bacterias Heterotróficas UFC/ml	$1,7x10^6$	<1	-.-	-.-	$5x10^2$
02	NMP. Bacterias Coliformes Totales /100 ml.	$3,5x10^6$	<1,8	50	$3x10^3$	<1,8
03	NMP. Bacterias Coliformes Termotolerantes /100 ml.	$3,5x10^6$	<1,8	0	$2x10^3$	<1,8
04	NMP. Escherichia coli /100 ml.	$1,7x10^6$	<1,8	0	0	<1,8
05	Determinación de Vibrio cholerae, presencia / 100 ml.	A	A	A	A	-.-
06	Determinación de Salmonella, presencia / 100 ml.	A	A	A	A	-.-
07	Huevos y larvas de Helmintos, quistes y ooquistes de protozoarios patógenos	-.-	A	-.-	-.-	0
08	Organismos de vida libre, como algas, protozoarios, copépodos, rotíferos, nematodos en todos sus estadios evolutivos	-.-	A	-.-	-.-	0
09	Formas Parasitarias	P	-.-	A	A	-.-
10	Cloro Residual libre mg/Lt.	-.-	-.-	-.-	-.-	* (0,3 a ≥0,5)
11	pH	5,37	5,98	6,5-8,5	5,5-9,0	* (6,5-8,5)
12	Turbiedad – UNT	5,37	0,0	5	100	5

*** A1= Aguas superficiales que pueden ser potabilizadas con desinfección * A2= Aguas superficiales que pueden ser potabilizadas con tratamiento convencional**
*** A: Ausencia *P: Presencia *<1,8: Ausencia *<1: Ausencia**

V CONCLUSION:

- La muestra analizada Nº **H236-15** (Agua superficial Lago Morona Cocha, a 10 mtrs. de la orilla), Microbiológicamente **"NO CUMPLE"** como aguas superficiales que pueden ser potabilizadas con desinfección y como aguas superficiales que pueden ser potabilizadas con tratamiento convencional, por no encontrarse dentro de los requisitos permisibles tomados como referencia; se reporta **Ausencia** de Vibrio cholerae y Salmonella.

- La muestra analizada Nº **C237-14** (Agua superficial Lago Morona Cocha, a 10 mtrs. de la orilla procesado por el sistema Equipo de Filtración **SAWYER)**, Microbiológicamente **"CUMPLE"** con los requisitos permisibles tomados como referencia.

- De acuerdo a los resultados de Análisis Parasitológico se determinó **Presencia** de formas parasitarias en la muestra de agua Nº **H236-15** (Algas-Diatomeas, Protozoario, Larva de Nematodo) y **Ausencia** en la muestra **C237-15**; se utilizó el método por filtración de membrana en 10 litros de agua filtrada, método de concentración y lavado en 05 litros de agua superficial.

Fuente :
- Control de Calidad del Agua – Primera Edición Mayo 2003 – Sunass.
- Decreto Supremo Nº 031-2010-SA "Aprueban Reglamento de la calidad del Agua para Consumo Humano"
- D.S. N° 002-2008-MINAM del 31/07/2008 El Peruano. "Aprueban los Estándares Nacionales de Calidad Ambiental para Agua Categoría 1 (Poblacional y Recreacional) – A1: Agua superficial que pueden ser potabilizadas con desinfección, A2: Agua superficial que pueden ser potabilizadas con tratamiento convencional.

Vº Bº [redacted] **Realizado por:** [redacted]

Iquitos, 08/04/15
MSVC./AAO.

Figure A.1. (Continued)

APPENDIX B: IRB STUDY APPROVAL LETTER

RESEARCH INTEGRITY AND COMPLIANCE
Institutional Review Boards, FWA No. 00001669
12901 Bruce B. Downs Blvd., MDC035 • Tampa, FL 33612-4799
(813) 974-5638 • FAX(813) 974-7091

9/14/2015

Stephanie Paredes
USF Department of Civil and Environmental Engineering
4202 E. Fowler Avenue
Tampa, FL 33620

RE: **Expedited Approval for Initial Review**
IRB#: Pro00023336
Title: Adoption of the SAWYER water filter as a Point of Use water treatment technology in Peru: behaviors, perceptions, and factors associated with filter use.

Study Approval Period: 9/14/2015 to 9/14/2016

Dear Ms. Paredes:

On 9/14/2015, the Institutional Review Board (IRB) reviewed and **APPROVED** the above application and all documents contained within, including those outlined below.

Approved Item(s):
Protocol Document(s):
ProtocolStephanieParedes

Consent/Assent Document(s):
Adult Consent Form English
Adult Consent Form Spanish
Assent Form English
Assent Form Spanish
Parental Consent Form English
Parental Consent Form Spanish

It was the determination of the IRB that your study qualified for expedited review which includes activities that (1) present no more than minimal risk to human subjects, and (2) involve only procedures listed in one or more of the categories outlined below. The IRB may review

Figure B.1. IRB study approval letter

research through the expedited review procedure authorized by 45CFR46.110 and 21 CFR 56.110. The research proposed in this study is categorized under the following expedited review category:

(6) Collection of data from voice, video, digital, or image recordings made for research purposes.

(7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

Your study qualifies for a waiver of the requirements for the documentation of informed consent as outlined in the federal regulations at 45CFR46.117(c) which states that an IRB may waive the requirement for the investigator to obtain a signed consent form for some or all subjects if it finds either: (1) That the only record linking the subject and the research would be the consent document and the principal risk would be potential harm resulting from a breach of confidentiality. Each subject will be asked whether the subject wants documentation linking the subject with the research, and the subject's wishes will govern; or (2) That the research presents no more than minimal risk of harm to subjects and involves no procedures for which written consent is normally required outside of the research context.

As the principal investigator of this study, it is your responsibility to conduct this study in accordance with IRB policies and procedures and as approved by the IRB. Any changes to the approved research must be submitted to the IRB for review and approval via an amendment. Additionally, all unanticipated problems must be reported to the USF IRB within five (5) calendar days.

We appreciate your dedication to the ethical conduct of human subject research at the University of South Florida and your continued commitment to human research protections. If you have any questions regarding this matter, please call 813-974-5638.

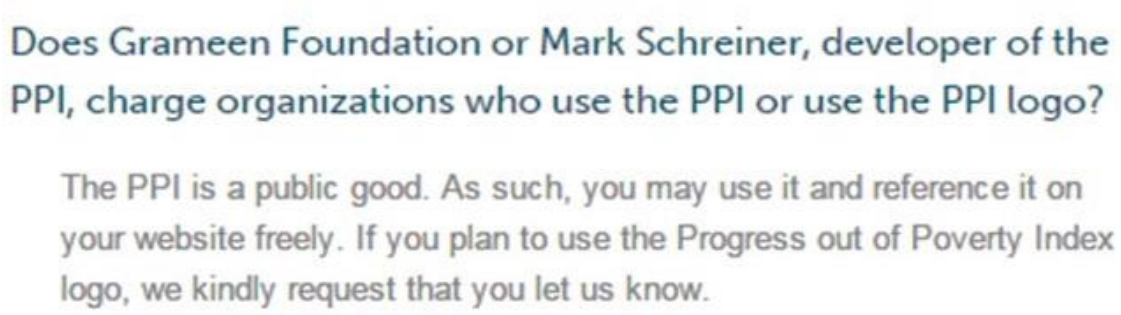
Sincerely,

John Schinka, Ph.D., Chairperson
USF Institutional Review Board

Figure B.1. (Continued)

APPENDIX C: COPYRIGHT PERMISSIONS

C.1 PPI Copyright Permission for Figures D.1 and D.2



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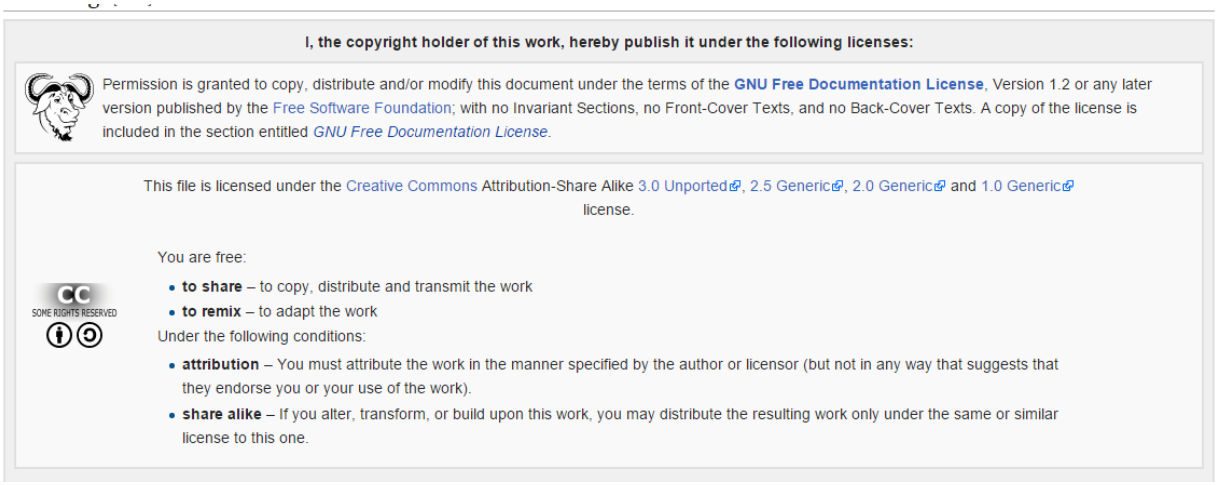
C.2 Wikicommons Copyright Permission

C.2.1 Copyright Permission for Figure 2-3 a)



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C.2.2 Copyright Permission for Figure 2-3 b)

This image rendered as PNG in other widths: 200px, 500px, 1000px, 2000px.

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Date	4 February 2010, 20:18 (UTC)
Source	• Peru_-_(Template).svg
Author	• Peru_-_(Template).svg: Huhsunqu • derivative work: Huhsunqu (talk)

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APPENDIX D: QUESTIONNAIRES AND LOOKUP TABLES

D.1 Original PPI® Household Questionnaire

PPI® Scorecard for Peru

To assist with collection, organizations can use the household roster located on the third page to assist with questions 1 & 2.

Entity	Name	ID	Date (DD/MM/YY)
Participant:			Joined:
Field agent:			Today:
Service point:			Household size:

Indicator	Response	Points	Score
1. How many members does the household have?	A. Seven or more	0	
	B. Six	7	
	C. Five	12	
	D. Four	17	
	E. Three	22	
	F. Two	27	
	G. One	34	
2. In the past week, how many household members ages 14 or older did any work? (not counting household chores)	A. One or none	0	
	B. Two	2	
	C. Three	6	
	D. Four or more	9	
3. What is the highest educational level that the female head/spouse completed?	A. None, pre-school, or kindergarten	0	
	B. Grade school (incomplete)	3	
	C. Grade school (complete), or high school (incomplete)	4	
	D. No female head/spouse	6	
	E. High school (complete), or non-university superior (incomplete)	7	
	F. Non-university superior (complete), or higher	13	
4. How many rooms are used only as bedrooms?	A. None	0	
	B. One	2	
	C. Two	4	
	D. Three or more	8	
5. What is the main material of the exterior walls?	A. Mud, matting, wattle and daub, adobe, stone with mud, or other	0	
	B. Wood, stone, stone blocks with mortar or cement, or brick or cement blocks	4	
6. What fuel does the household most frequently use for cooking?	A. Charcoal, kerosene, or other	0	
	B. Firewood	3	
	C. Gas (LPG or natural), electricity, or does not cook	7	
7. Does the household have a refrigerator/freezer?	A. No	0	
	B. Yes	3	
8. Does the household have a blender?	A. No	0	
	B. Yes	6	
9. How many color televisions does the household have?	A. None	0	
	B. One	5	
	C. Two or more	9	
10. Does the household have a cellular telephone?	A. No	0	
	B. Yes	7	

By Mark Schreiner of Microfinance Risk Management L.L.C., developer of the PPI. Score:

Figure D.1. PPI household questionnaire. Can be downloaded at http://www.progressoutofpoverty.org/country/peru

Back-page Worksheet:
Household Roster and Work Status

At the start of the interview, read to the respondent: Please tell me the names and ages of all household members, that is all people—regardless of blood relationship—who stay or live permanently in the same residence, who share their main meals, and who cooperate together to fulfill their other basic needs. This includes whomever the household head thinks it should include. A household may have just one person. Do not forget absent members or newborns. Do not count live-in domestic servants nor lodgers.

Write the names and ages all household members. For each member 14-years-old or older, ask whether he/she did any work in the past week (not including household chores).

See the Interview Guide for more detail about the definitions of work, past week, and household member.

Count the number of household members, write it next to "Household size:" in the scorecard header, and mark the corresponding response to Question 1. Count the number of household members who work, and mark the response for Question 2.

Name of household member	Age	If <name> is 14 or older, then ask: In the past week, did <name> do any work? (not counting household chores)
1.		No Yes
2.		No Yes
3.		No Yes
4.		No Yes
5.		No Yes
6.		No Yes
7.		No Yes
8.		No Yes
9.		No Yes
10.		No Yes
11.		No Yes
12.		No Yes
13.		No Yes
14.		No Yes
15.		No Yes
Total members:		Total workers:

This PPI was created in December 2012, based on data from 2010. For more information about the PPI, please visit www.progressoutofpoverty.org

Figure D.1. (Continued)

D.2 Original PPI® Lookup Tables

Peru PPI®: Lookup Tables

The following lookup tables convert PPI scores to the poverty likelihoods below each of the poverty lines.

PPI Score	National Food (%)	100% National (%)	150% National (%)	200% National (%)
0-4	73.7	100.0	100.0	100.0
5-9	70.6	98.5	99.5	100.0
10-14	57.5	95.8	99.4	100.0
15-19	43.3	91.7	99.4	100.0
20-24	39.7	84.5	96.7	99.6
25-29	27.5	77.0	94.8	99.3
30-34	17.8	66.9	90.7	98.1
35-39	9.5	52.0	85.3	95.4
40-44	4.8	38.9	76.8	93.6
45-49	1.4	26.5	63.9	83.9
50-54	0.6	16.8	53.6	77.2
55-59	0.0	8.1	38.5	67.9
60-64	0.0	3.6	25.8	53.3
65-69	0.0	1.5	14.5	38.3
70-74	0.0	0.7	6.5	20.2
75-79	0.0	0.0	2.1	8.3
80-84	0.0	0.0	0.0	4.5
85-89	0.0	0.0	0.0	0.0
90-94	0.0	0.0	0.0	0.0
95-100	0.0	0.0	0.0	0.0

Source: Microfinance Risk Management, L.L.C. Based on Peru's 2010 National Household Survey.

This PPI was created in December 2012, based on data from 2010. For more information about the PPI, please visit www.progressoutofpoverty.org

Figure D.2. PPI lookup tables. Can be downloaded at http://www.progressoutofpoverty.org/country/peru

Peru PPI®: Lookup Tables

The following lookup tables convert PPI scores to the poverty likelihoods below each of the poverty lines.

PPI Score	USAID Extreme	Int'l 2005 PPP $1.25	Int'l 2005 PPP $2.50	Int'l 2005 PPP $3.75
0-4	83.5	45.4	72.6	100.0
5-9	78.8	12.3	66.4	93.7
10-14	72.2	4.7	47.4	90.1
15-19	58.2	2.2	40.3	80.5
20-24	53.5	2.1	35.2	72.6
25-29	46.1	1.9	25.1	61.5
30-34	32.3	1.0	16.7	48.8
35-39	22.4	0.4	8.9	34.4
40-44	18.4	0.3	4.8	23.6
45-49	8.0	0.1	1.9	11.8
50-54	4.3	0.0	0.7	5.2
55-59	2.3	0.0	0.0	2.3
60-64	1.0	0.0	0.0	1.2
65-69	0.3	0.0	0.0	0.3
70-74	0.2	0.0	0.0	0.0
75-79	0.0	0.0	0.0	0.0
80-84	0.0	0.0	0.0	0.0
85-89	0.0	0.0	0.0	0.0
90-94	0.0	0.0	0.0	0.0
95-100	0.0	0.0	0.0	0.0

Source: Microfinance Risk Management, L.L.C. Based on Peru's 2010 National Household Survey.

This PPI was created in December 2012, based on data from 2010. For more information about the PPI, please visit www.progressoutofpoverty.org

Figure D.2. (Continued)

D.3 Questionnaire – Household and Personal Questions in Spanish

I. DEMOGRAFIA:

1. Centro poblado: _____ 2. Distrito: _____
3. RURAL / URBANO 4. Religión: _____ 5. Sexo: M / F
6. Edad: _____ 7. Donde naciste: _____

II. SOCIO-ECONOMICO

A. General

1. Soltero / Casados / Convivientes
2. ¿Cuál es el más alto nivel de educación del jefe/jefa de la casa y su pareja?
   Jefe_____Jefa_____
3. Nivel de estudio de hijos (público, privado, religioso)

4. ¿Cuál es la fuente principal de ingresos del hogar? _____
5. Trabajo fijo / temporal 6. Ocupación _____
7. La familia posee:

BICICLETA _____ MOTO_____ MOTOTAXI_____ CARRO/CAMIONETA _____
BUS/CAMION_____ Máquinas Agrícolas_____

a. En el hogar contamos con:

Televisor ____Televisor con cable_____ Computadora _____ Computadora con internet _____ WIFI_____

B. Indicadores Económicos – PPI PERU

1. ¿Cuántos miembros tiene el hogar? _____
2. La semana pasada, ¿Cuántos miembros del hogar de 14 años y más de edad tuvieron algún trabajo?

Miembro del hogar	Edad	Si más de 14, ¿ha trabajado en la semana pasada?
1.		
2.		
3.		
4.		
5.		
6.		
7.		

3. ¿Cuál es el último año o grado de estudios y nivel que aprobó la jefa/esposa del hogar?

a. Ninguno, inicial b. primaria incompleta c. primaria completa o secundaria incompleta

d. No hay jefa o esposa e. Secundaria completa o instituto incompleta f. instituto completa o mas

4. ¿Cuántas habitaciones se usan exclusivamente para dormir? _____

5. El material predominante en las paredes exteriores es...?

Figure D.3. Household and personal questions in Spanish

a. Tapia, Adobe, plástico, estera, piedra con barro
b. Madera, piedra o sillar con cal o cemento, ladrillo o bloque de cemento

6. ¿Cuál es el combustible que se usa con mayor frecuencia en el hogar para cocinar los alimentos?
a. Carbón, kerosene, u otro b. leña c. gas, electricidad, o no cocinan

7. ¿El hogar tiene una refrigeradora/congeladora? A. SI B. NO

8. ¿El hogar tiene licuadora? A. SI B. NO

9. ¿Cuántos televisores a colores tiene el hogar? A. Ninguno B. Uno C. Dos o más

10. ¿El hogar tiene teléfono celular? A. SI B. No

III. INFORMACION WASH

PREGUNTA y OBSERVA

A. Acceso al agua

1. ¿Tienen conexión a la red pública de agua? SI / NO
2. ¿Tienen agua corriente dentro de la casa? SI / NO
3. Si no, ¿cómo almacenan el agua?: _____

4. ¿Qué opina sobre la calidad de agua? _____

5. ¿Hacen algún tipo de tratamiento al agua que consumen? ¿Antes de obtener un filtro, como trataban el agua?

_____

B. Almacenamiento de Agua

6. ¿Tienen un pozo para almacenar agua? SI / NO 7. ¿Tienen tanque eternit? SI / NO
8. ¿Almacenan agua de alguna manera dentro de la casa? ¿Como? SI / NO

_____

C. Saneamiento

9. Letrina / un wáter manual / wáter con arrastre hidráulico

10. ¿Está conectada al desagüe? SI / NO Si no, ¿cómo manejan los residuos?: _____

11. El baño tiene: ducha / lavadero / water

D. Lavado de manos

12. ¿Prepara alimentos? SI / NO
13. ¿Cuándo se lava las manos?

Antes de comer	*Antes de cocinar*	*Después de ir al baño*	*Después de cambiar pañales*
Antes de lactar	*Después de tocar animales*		

14. Como se lava las manos?

15. Usas jabón? No / a veces / siempre

Figure D.3. (Continued)

16. ¿Dónde se lavas las manos? _____

Lavadero con agua corriente / lavadero sin agua corriente / tina con agua corriente / tina sin agua corriente.

IV. HEALTH BELIEF MODEL

¿Cuáles son algunas consequencias de tener o que sus hijos tengan diarrhea?

_____

¿Puedes dar ejemplos de enfermedades relacionados a la baja calidad de agua?

_____

¿Viste algún beneficio en el filtro que te impulsara a usarlo?_____

¿Tenías alguna duda de usar los filtros SAWYER?_____

¿Hubo una acción, señal, o experiencia que te convenció probar el filtro SAWYER?

_____

¿Qué otras formas de tratar el agua conoces?_____

1. COMPRA del FILTRO

¿Cómo te enteraste del filtro SAWYER?_____

¿Qué lo impulso a comprar un filtro SAWYER? _____

¿Cuándo compraron un filtro SAWYER? _____

¿En qué manera pagaron el filtro? Una cuota / múltiples cuotas / crédito / depósito directo

¿Alguien ayudo para instalar el filtro? SI / NO

¿Comprarían otro filtro? SI / NO

2. USO DEL FILTRO

¿El filtro está instalado? SI / NO

¿Como?

¿Cuantas personas usan agua del filtro? _____ ¿Todos de la misma familia? SI / NO

¿Quién se encarga en mantener el filtro? _____

¿Cada cuánto lavas el filtro (si eres responsable)? _____

¿En algún momento han tenido que usar materiales no incluido en el KIT para usar el filtro eficientemente? SI / NO

¿Qué?_____

¿Almacenan agua filtrada? Como/donde

¿Haz recomendado el filtro a un amigo o familiar? ¿Por qué o porque no?

Figure D.3. (Continued)

D.4 Questionnaire – Household and Personal Questions in English

I. DEMOGRAPHICS:

1. Community: _____ 2. district: _____
3. RURAL / URBAN 4. Religion: _____ 5. Sex: M / F
6. Age: _____ 7. Birthplace: _____

2. SOCIO-ECONOMIC

A. General

1. Single / married / cohabitating
2. Highest level of education of head of household and partner.
   Male_____Female_____
3. Children's level of education; public, private, religious

4. What is the main source of income for the house? _____
5. Salaried / Seasonal 6. Occupation _____

7. The family has:

Bike _____ motorcycle____Moto taxi____ car or truck_____bus or truck_____ Agricultural machinery_____

3. In the house, we have:

Television____Television with cable_____ Computer_____Computer with internet_____ WIFI_____

B. Economic Indicators, PPI PERU

1. How many members does the household have? _____
2. In the past week, how many household members ages 14 or older did any work?

Member of the house	Age	If older than 14, have they worked in the past week?
1.		
2.		
3.		
4.		
5.		
6.		

Figure D.4. Household and personal questions in English

7.		

3. What is the highest level of education that the female head of house/spouse completed?
   a. None, preschool, kinder b. grade school (incomplete) c. grade school (complete) or high school (incomplete) d. no female head/spouse e. high school (complete) or non-university superior (incomplete) f. non-university superior (complete), or higher
4. How many rooms are used only as bedrooms? _____
5. The main material of the exterior walls are…
   a. Mud, matting, watter and daub, adobe, stone with mud, or other
   b. Wood, stone, stone blocks with mortar or cement, or brick or cement blocks
6. What fuel does the household most frequently use for cooking?
   a. Charcoal, kerosene, or other b. firewood c. gas, electricity, or does not cook
7. Does the household have a freezer/refrigerator? A. Yes B. No
8. Does the household have a blender? A. Yes B. No
9. How many color televisions does the household have? A. None B. One C. Two or more
10. Does the household have a cellular telephone? A. Yes B. No.

3. WASH RELATED INFORMATION

ASK and OBSERVE

A. Water access

1. Are you connected to the municipal water supply? YES / NO
2. Do you have running water within the home? YES / NO
3. If you don't have running water, how do you store water in the home? _____
4. What's your opinion on the water quality? _____
5. Do you treat water before consuming? Before having a Sawyer filter, how did you treat water within the home? _____

B. Water Storage

6. Do you have underground water storage? YES / NO
7. Do you have a roof tank? YES / NO
8. Do you store any water within the home? YES / NO How?

C. Sanitation Facility

9. Latrine / manual flush toilet / automatic flush toilet
10. Are you connected to the sewer system? YES / NO If not, how do you manage the waste?

    _____
11. The bathroom has: shower / sink / toilet

D. Hand washing practices

12. Do you prepare the food?
13. When do you wash your hands?

Before eating	*Before cooking*	*After going to the bathroom*	*After changing diapers*
Before breastfeeding	*After touching animals*		

14. How do you wash your hands?

Figure D.4. (Continued)

15. Do you use soap? No / sometimes / always
16. Where do you wash your hands? _____

Sink with running water / sink without running water / plastic tub with running water / plastic tub without running water

4. HEALTH BELIEF MODEL

What are some of the consequences if you or your children get diarrhea?

_____

Can you name any specific diseases caused by poor water quality?

_____

What benefits did you see in the SAWYER filter that lead you to use it? _____

What doubts did you have about using the SAWYER water filter? _____

Was there an action, sign, or experience that convinced you to try the SAWYER water filter?

_____

Can you list other ways to treat your water before drinking it? _____

5. PURCHASE of FILTER

How did you hear about the SAWYER filter? _____

What lead you to purchase a filter? _____

When did you buy your SAWYER filter? _____

How did you pay for the filter? One payment / multiple payments / credit / direct deposit

Did someone help you install the water filter? YES / NO

Would you buy another SAWYER filter? YES / NO

6. USO DEL FILTRO

Is the filter currently installed? YES / NO

How (bucket adapter, directly to faucet, etc.)

How many people use the filter? _____ All from the same family? YES / NO

Who's in charge of filter maintenance? _____

How often to you backwash if you're the one responsible? _____

Have you ever had to use something not included in the kit to use the filter? YES / NO What? _____

Do you store filtered water? YES / NO How, where? _____

Have you recommended this filter to Friends or family? Why or why not. _____

Figure D.4. (Continued)

D.5 Health Belief Model Written Likert Scale Survey in Spanish

HEALTH BELIEF MODEL – written questions

Contesta con

1. **Muy de acuerdo 2. De acuerdo 3. Sin opinión 4. En desacuerdo 5. Muy en desacuerdo.**

1. La diarrea no es una enfermedad grave.

Muy de acuerdo 2. De acuerdo 3. Sin opinión 4. En desacuerdo 5. Muy en desacuerdo.

2. Las enfermedades diarreicas amenazan la salud de los niños.

Muy de acuerdo 2. De acuerdo 3. Sin opinión 4. En desacuerdo 5. Muy en desacuerdo.

3. Las enfermedades diarreicas no tienen graves consecuencias económicas.

Muy de acuerdo 2. De acuerdo 3. Sin opinión 4. En desacuerdo 5. Muy en desacuerdo.

4. Las enfermedades diarreicas afectan el desarrollo del niño al largo plazo.

Muy de acuerdo 2. De acuerdo 3. Sin opinión 4. En desacuerdo 5. Muy en desacuerdo.

¿Cuáles son algunas consequencias de tener o que sus hijos tengan diarrhea?

_____

5. Las enfermedades diarreicas no afectan mucho mi vida.

Muy de acuerdo 2. De acuerdo 3. Sin opinión 4. En desacuerdo 5. Muy en desacuerdo.

6. Las enfermedades diarreicas causan dificultades a mis familiares o amigos cercanos.

Muy de acuerdo 2. De acuerdo 3. Sin opinión 4. En desacuerdo 5. Muy en desacuerdo.

7. Es probable que tenga diarrea dentro de poco.

Muy de acuerdo 2. De acuerdo 3. Sin opinión 4. En desacuerdo 5. Muy en desacuerdo.

8. Tomar agua cruda no arriesga mi salud.

Muy de acuerdo 2. De acuerdo 3. Sin opinión 4. En desacuerdo 5. Muy en desacuerdo.

¿Puedes dar ejemplos de enfermedades relacionados a la baja calidad de agua?

_____

9. El filtro SAWYER me ahorra dinero al largo plazo.

Muy de acuerdo 2. De acuerdo 3. Sin opinión 4. En desacuerdo 5. Muy en desacuerdo.

10. La salud de mi familia no es afectada por el uso del filtro SAWYER.

Figure D.5. Health Belief Model survey questions in Spanish

Muy de acuerdo 2. De acuerdo 3. Sin opinión 4. En desacuerdo 5. Muy en desacuerdo.

11. El filtro SAWYER me ahorra en tiempo.

Muy de acuerdo 2. De acuerdo 3. Sin opinión 4. En desacuerdo 5. Muy en desacuerdo.

12. El filtro SAWYER disminuye el riesgo de las enfermedades diarreicas.

Muy de acuerdo 2. De acuerdo 3. Sin opinión 4. En desacuerdo 5. Muy en desacuerdo.

¿Viste algún beneficio en el filtro que te impulsara a usarlo? _____

_____

13. El precio del filtro SAWYER es alto.

Muy de acuerdo 2. De acuerdo 3. Sin opinión 4. En desacuerdo 5. Muy en desacuerdo.

14. La disponibilidad del filtro SAWYER es bajo.

Muy de acuerdo 2. De acuerdo 3. Sin opinión 4. En desacuerdo 5. Muy en desacuerdo.

15. No me agrada tener que adaptarme a una nueva tecnología.

Muy de acuerdo 2. De acuerdo 3. Sin opinión 4. En desacuerdo 5. Muy en desacuerdo.

16. No confió en una tecnología desconocida.

Muy de acuerdo 2. De acuerdo 3. Sin opinión 4. En desacuerdo 5. Muy en desacuerdo.

¿Tenías alguna duda de usar los filtros SAWYER? _____

_____

17. Yo o un miembro de mi familia ha sufrido una enfermedad relacionado con el agua.

Muy de acuerdo 2. De acuerdo 3. Sin opinión 4. En desacuerdo 5. Muy en desacuerdo.

18. Un familiar o amigo me recomendó el producto.

Muy de acuerdo 2. De acuerdo 3. Sin opinión 4. En desacuerdo 5. Muy en desacuerdo.

19. La turbiedad de agua durante la época de lluvia me hizo buscar otra forma de tratar el agua.

Muy de acuerdo 2. De acuerdo 3. Sin opinión 4. En desacuerdo 5. Muy en desacuerdo.

20. Vi una demostración del producto antes de decidir usarlo.

Muy de acuerdo 2. De acuerdo 3. Sin opinión 4. En desacuerdo 5. Muy en desacuerdo.

Figure D.5. (Continued)

¿Hubo una acción, señal, o experiencia que te convenció probar el filtro SAWYER?

_____

21. Tenía dudas sobre el filtro al principio.

Muy de acuerdo 2. De acuerdo 3. Sin opinión 4. En desacuerdo 5. Muy en desacuerdo.

22. Si veo algún problema en el distrito, lo reporto a las autoridades.

Muy de acuerdo 2. De acuerdo 3. Sin opinión 4. En desacuerdo 5. Muy en desacuerdo.

23. No me siento seguro/a en mis habilidades de tratar agua antes de consumirla.

Muy de acuerdo 2. De acuerdo 3. Sin opinión 4. En desacuerdo 5. Muy en desacuerdo.

24. Yo puedo encontrar la manera de pagar por mis necesidades de salud.

Muy de acuerdo 2. De acuerdo 3. Sin opinión 4. En desacuerdo 5. Muy en desacuerdo.

¿Qué otras formas de tratar el agua conoces? _____

_____

Figure D.5. (Continued)

D.6 Health Belief Model Written Likert Scale Survey in English

1. HEALTH BELIEF MODEL

Answer with

1. Strongly agree 2. Agree 3. No opinion 4. Disagree 5. Strongly disagree

Perceived seriousness

1. Diarrheal diseases aren't serious. R
2. Diarrheal diseases are a serious health issue for children.
3. Diarrheal diseases do not have serious financial consequences. R
4. Diarrheal diseases affect long term development of children.

What are some of the consequences if you or your children get diarrhea?

_____

_____

Perceived susceptibility

5. Diarrheal diseases don't affect my life too much. R
6. Diarrheal diseases cause difficulties for those who are close to me.
7. It is likely that I will have diarrhea soon.
8. Drinking untreated water does not pose a risk to my health. R

Can you name any specific diseases caused by poor water quality?

_____

_____

Perceived Benefits

9. The SAWYER water filter saves me money in the long run.
10. The health of my family is unaffected by the use of the SAWYER water filter. R
11. The SAWYER water filter saves me time.
12. The SAWYER water filter reduces my risk of diarrheal diseases.

What benefits did you see in the SAWYER filter that lead you to use it?

_____

Perceived barriers

13. The cost of the SAWYER water filter is high.
14. The availability of the SAWYER water filter in the market is low.
15. I don't like having to adapt to a new technology.
16. I don't trust an unknown technology.

What doubts did you have about using the SAWYER water filter?

_____

Figure D.6. Health Belief Model questions in English

Cues to Action

17. I or a family member has suffered from an illness related to water quality.
18. I was recommended this product by family or a friend.
19. The turbidity of the water during the rainy season made me look for another water treatment option.
20. I saw a product demonstration before I decided to use the product.

Was there an action, sign, or experience that convinced you to try the SAWYER water filter?

_____
_____

Self-Efficacy

21. I was hesitant to try this new product at first.
22. If I see an issue in the district, I typically speak up about it.
23. I do not feel confident in my own ability to treat water before I consume it.
24. I can find a way to pay for health related necessities.

Can you list other ways to treat your water before drinking it?

_____

Figure D.6. (Continued)