Project Number: JXR-2010

A Public Health Project in Methods of *Schistosomiasis haematobium* Control in Adasawase, Ghana

A Major Qualifying Project

submitted to the Faculty of

WORCESTER POLYTECHNIC INSTITUTE

in partial fulfillment of the requirements for the

Degree of Bachelor of Science

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1. Ghana
2. Schistosomiasis
3. Filtration

Abstract

Schistosomiasis is a parasitic disease that is endemic in Africa. Adasawase is a rural village in eastern Ghana that had a 49.8% prevalence rate in 2008. This project utilized a public health approach to further control schistosomiasis. Infection rates in schoolchildren were determined by urine testing and a filtration system was built for the town's water recreation area. Surveys were used to assess knowledge and a health education plan was implemented. As of 2010, infection rates have decreased to 14.5%.

ACKNOWLEDGEMENTS

We would like to thank our advisers Professor Jill Rulfs and Jeanine Plummer for their continued guidance and support throughout our project. We would also like to acknowledge Karen Konsinski for providing us the opportunity to complete our MQP in Ghana and advising us while we were there in conjunction with completing her doctorate thesis research. We are very grateful for the experiences gained while working both on and off campus. We would also like to express thanks to following individuals that comprised our research team while on ground: Mr. Osabarima Kwame Tia II (the Chief of Adasawase), Mr. Michael Nii Adjei (cultural translator), Mr. Dickson Osabutey (lab technician), Mr. Quincy Moore (research partner), Mr. Kofi Danquah (Head Mason), Mr. Sammy Tetteh (construction team), Mr. Ernest Asante (construction team), Mr. Felix Adjei (cultural translator), and Ms. Mavis Akyaamaa (cultural translator).

Civil Engineering MQP Capstone Design Statement

The purpose of this Major Qualifying Project was to use a public health approach to control schistosomiasis in Adasawase, Ghana. The Civil Engineering component of this project was to design and build a filtration system for a water recreation area in Adasawase. The recreation facility was built by Karen Kosinski in 2008 – 09. After surveying the children on their use of the pool, a holding/settling tank and roughing filter were sited, designed and built. This project included the following capstone design components:

Economic

- Team used local materials and local workers, and compiled pricing information for the purchase of materials.

Environmental

- Design reduces contaminants without the use of chlorine, minimizing unsafe discharge to the surrounding environment.

Ethical

- Design balances cost efficiency against community need.

Health and Safety

- Filtration system design strives to limit the stagnation of water, thereby reducing turbidity and limiting the bacterial growth creating a safer recreating area.

Political

- Design builds off the needs set by the chief in Kosinski's project.

Social

- Design responds to various social challenges, including vandalism, user error, and willingness to participate.

Sustainability

- Design maximizes water conservation while minimizing future community contributed costs.

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CHAPTER 1: INTRODUCTION

Schistosomiasis is one of the thirteen neglected tropical diseases that is chronic, debilitating, and poverty promoting (Hotez *et al*. 2007). Schistosomiasis ranks second to malaria among parasitic diseases with regard to the number of people infected and those at risk (Steinmann *et al*. 2006). The causative agents are blood flukes, which are trematode worms of the genus *Schistosoma* (Fenwick and Utzinger 2008). The larval forms of the parasite are released by freshwater snails, and subsequently infect people through the skin during contact with infested water. Once in the body, the larvae develop into adult schistosomes that live in the blood vessels around the bladder. Eggs are produced and released through the urine or feces to continue the life cycle of the parasite. Eggs can also get trapped in the human host's bladder and cause an immune response or progressively damage organs (Acha and Szyfres 2001).

The disease is prevalent in tropical and sub-tropical areas and especially in poor communities without potable water and adequate sanitation (World Health Organization 2010). There are limited accurate data on the epidemiological status and prevalence worldwide, since global estimates for the number of people infected and at risk of infection are extrapolated from surveys at the country level (Engels *et al*. 2002). It is estimated that approximately 207 million people live with the disease (King and Dangerfield-Cha 2008) and another 700 million may be at risk because of agricultural, domestic, and recreational activities that expose them to contaminated water (World Health Organization 2010).

The goal of this Major Qualifying Project (MQP) was to evaluate control methods for schistosomiasis in Adasawase, a rural Ghanaian village (Kosinski unpublished). Kosinski began research in 2007 to measure schistosomiasis infection rates and assess control methods including mass treatment and construction of an alternative water recreation area.

This MQP focused on analyzing infection rates and the impact of interventions on infection rates, constructing a filtration system for the water recreation facility, and developing an educational program for schoolteachers to raise awareness about the disease.

CHAPTER 2: BACKGROUND

Schistosomiasis is endemic is 76 countries worldwide (Engels *et al*. 2002) and 46 of these countries are in Africa. Of the 46 endemic countries in Africa, 29 of them have over 1 million people infected. There were five African countries where the estimated number of infections in 2006 was in excess of 10 million: Nigeria (28.8 million), United Republic of Tanzania (19.0 million), Ghana (15.2 million), Democratic Republic of the Congo (14.9 million), and Mozambique (13.2 million) (Steinmann *et al*. 2006).

In Ghana, the World Health Organization (2010) estimated that 17.6 million people were infected in 2008. Based on the population density for that year (Central Intelligence Agency 2010) this represents 73% of the population. Although the global epidemiological situation of schistosomiasis has changed over the last fifty years through successful control programs, 85% of infected people are estimated to be on the African continent where few control programs have been established (King and Dangerfield-Cha 2008). In relation to disease burden, there is a growing discrepancy between sub-Saharan Africa and the rest of the world (Engels *et al*. 2002).

2.1 CLASSIFICATION OF SCHISTOSOMES AND EPIDEMIOLOGY

Schistosomiasis refers to the disease acquired by parasitic blood flukes that belong to the genus *Schistosoma*. The genus *Schistosoma* (Greek: *schisto*, "cleft;" *soma*, "body) includes approximately 19 species that have historically been divided into different groups centering on *S. haematobium*, *S. japonicum*, *S. indicum*, and *S. mansoni* (Coon 2005). These four species are known to affect humans primarily (Conlon 2005). The grouping also reflects similarities in egg morphology and the genera of intermediate snail hosts. Differences between schistosome species lie in the preferred intermediate host and the localization of the adult parasites in the host's circulatory system (Acha and Szyfres 2001).

The genus contains many species that infect animals, with multiple species that are pathogenic to humans. The most important species to humans that are prevalent worldwide are *S. haematobium*, *S. japonicum*, and *S. mansoni* (Coon 2005). *S. haematobium* causes urinary schistosomiasis in most African countries and the Middle East, including the islands of Madagascar and Mauritius (World Health Organization 2010) and 119 million people are infected worldwide (de Silva *et al*. 2003). *S. mansoni* causes intestinal and hepatic schistosomiasis in South America, the Caribbean, most African countries north of the equator (Egypt, Libya, Sudan, Somalia, Mali, Senegal, and Mauritania) and the Middle East (World Health Organization 2010), and 67 million people are infected worldwide (de Silva *et al*. 2003). Lastly, *S. japonicum* causes intestinal schistosomiasis in the Far East, especially in China and the Philippines, and 1 million people are infected worldwide (de Silva *et al*. 2003). Figure 1 shows the geographical distribution of hepatic, urinary, and intestinal schistosomiasis infections in endemic areas as of 2008 (National Travel Health Network and Centre 2010). As can be seen in Figure 1, the African continent has the highest prevalence of both hepatic and urinary/intestinal schistosomiasis, with Brazil and China also being heavily affected by hepatic/intestinal schistosomiasis.

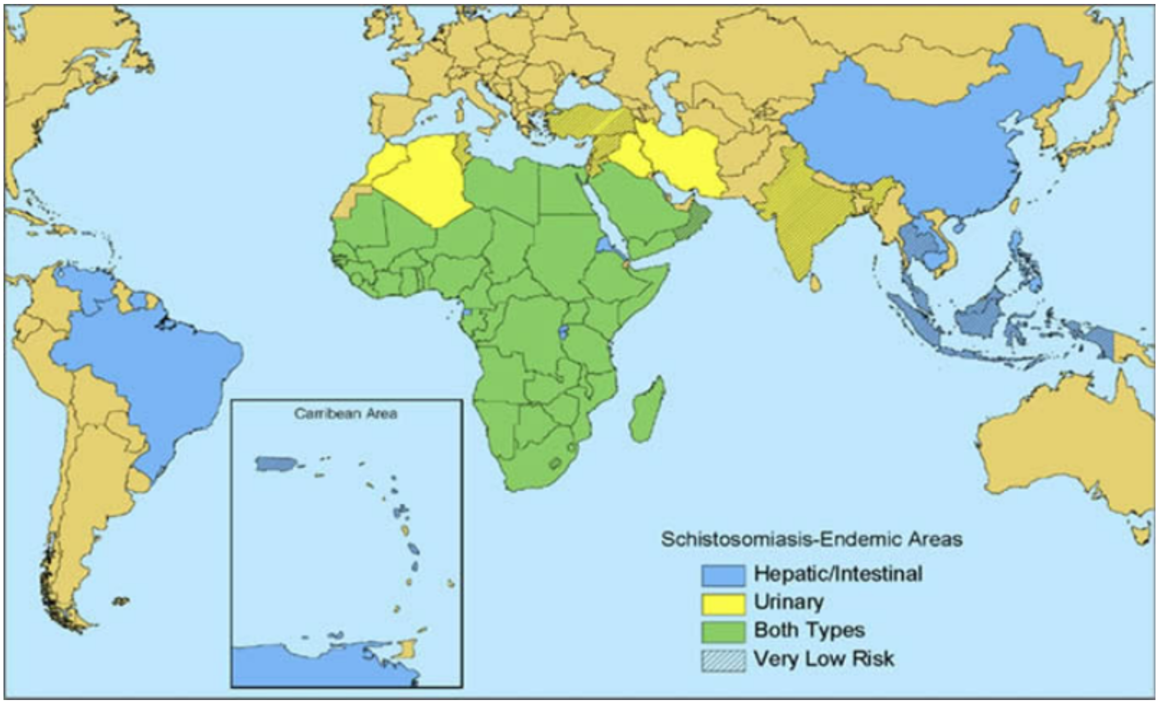

Figure 1. Geographic Distribution of Schistosomiasis (National Travel Health Network and Centre 2010)

The taxonomic classifications of schistosomes are shown in Table 1 (Temple 2004). Schistosomes belong to the phylum Platyhelminthes (Greek: *platy*, “flat;” *helminth*, “worm”) which is divided into four classes: Cestoda (tapeworms), Monogena (monogenetic flukes), Trematoda (digenetic and aspidogastrean flukes) and Turbellaria (planarians) (Brusca 2003). All trematodes are parasites, and there are several medically important species that affect humans.

Table 1. Taxonomic Classification of Schistosomes (Coon 2005)

Taxonomy	**Name**
Kingdom	Animalia
Phylum	Platyheminthes (Flatworms)
Class	Trematoda (Flukes)
Subclass	Digenea
Order	Strigeida
Family	Schistosomatidae
Subfamily	Schistosomatinae
Genus	*Schistosoma*
Species	*S. haematobium*
	S. japonicum
	S. mansoni

Adult schistosomes are white or grey worms with white cylindrical bodies that are about 7 to 20 mm in length. The body contains two terminal suckers, an oral and ventral sucker to allow the worm to maintain its position in the vein lumen (Conlon 2005), a complex tegument, a blind digestive tract, and reproductive organs (Gryseels *et al*. 2006). The males are short and broad and the females are long and thin (Gryseels *et al*. 2006). An adult male fluke measures 10 to 15 mm in length and is 1mm wide. The adult female is 20 mm in length and 250 µm wide (Youssef *et al*. 1998).

Schistosomes are placed in the sub-class Digenea, because of the defining characteristic of alternating generations in their life cycle. This means that when an egg hatches, it produces a larval form that eventually reproduces asexually. The resulting offspring from this asexual reproduction eventually mature into sexually reproductive adults. Therefore, the reproductive behavior changes with each successive generation (Coon 2005).

The order Strigeida includes several families. Schistosomes belong to the family Schistosomatidae, which includes species that have separate sexes, a distinctive characteristic of the Trematoda class (Gryseels *et al*. 2006). Schistosome adults live in a host's circulatory system, hence the term "blood flukes." They belong to the subfamily Schistosomatinae, which encompasses those species with a well-developed gynecophoral canal extending to the posterior end of the body. The gynecophoral (Greek: *gyn*, "female;" *phoros*, "to carry") canal is a deep groove in the body of the male worm into which the longer and thinner female inserts herself (see Figure 2). The male will carry her for life and copulation will continually persist. As permanently embraced couples, the schistosomes live within the perivesical veins around the bladder (S. *haematobium*) or mesenteric (other species) venous plexus (Coon 2005). They feed on blood and globulins through anaerobic glycolysis and regurgitate debris into the host's bloodstream (Gryseels *et al*. 2006).

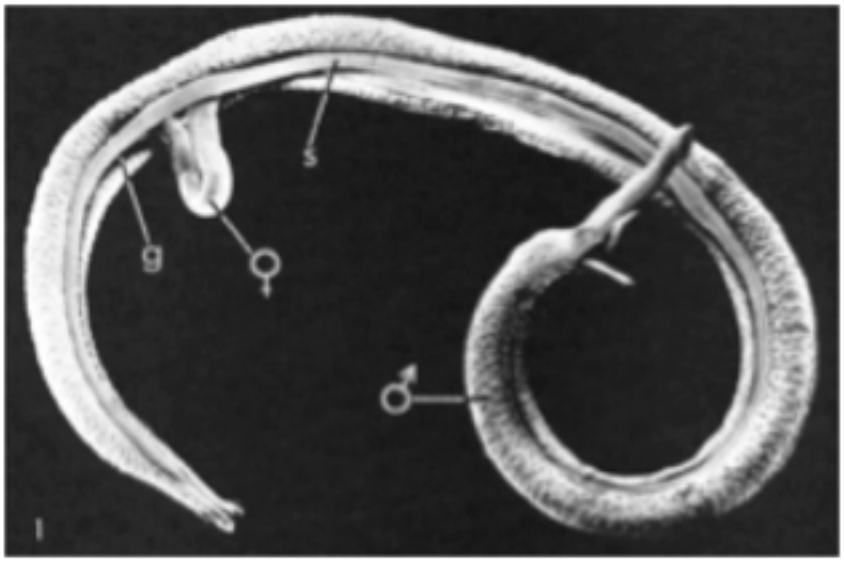

Figure 2. Scanning electron microscopy of integumental surfaces of *Schistosoma haematobium* (Kuntz *et al*. 1977)The “g” indicates the gynecophoral canal and the “s” indicates the smooth lining of the canal.

2.2 LIFE CYCLE

The life cycle of *S. haematobium* depicted in Figure 3 begins with an infected human, who is the definitive host. When this individual urinates near a water body, worm eggs are released through the urine and hatch into miracidia upon contact with the water. Miracidia are the larval form in the worm’s development and mobile organisms that are capable of swimming. Using chemotaxis (chemical signals), they find and infect the intermediate host, a *Bulinus* snail (shown in Figure 4), by penetrating the soft tissue. The miracidia have a short life span and are infective to the snail for 8 to 12 hours after hatching (Cook and Zumla 2009).

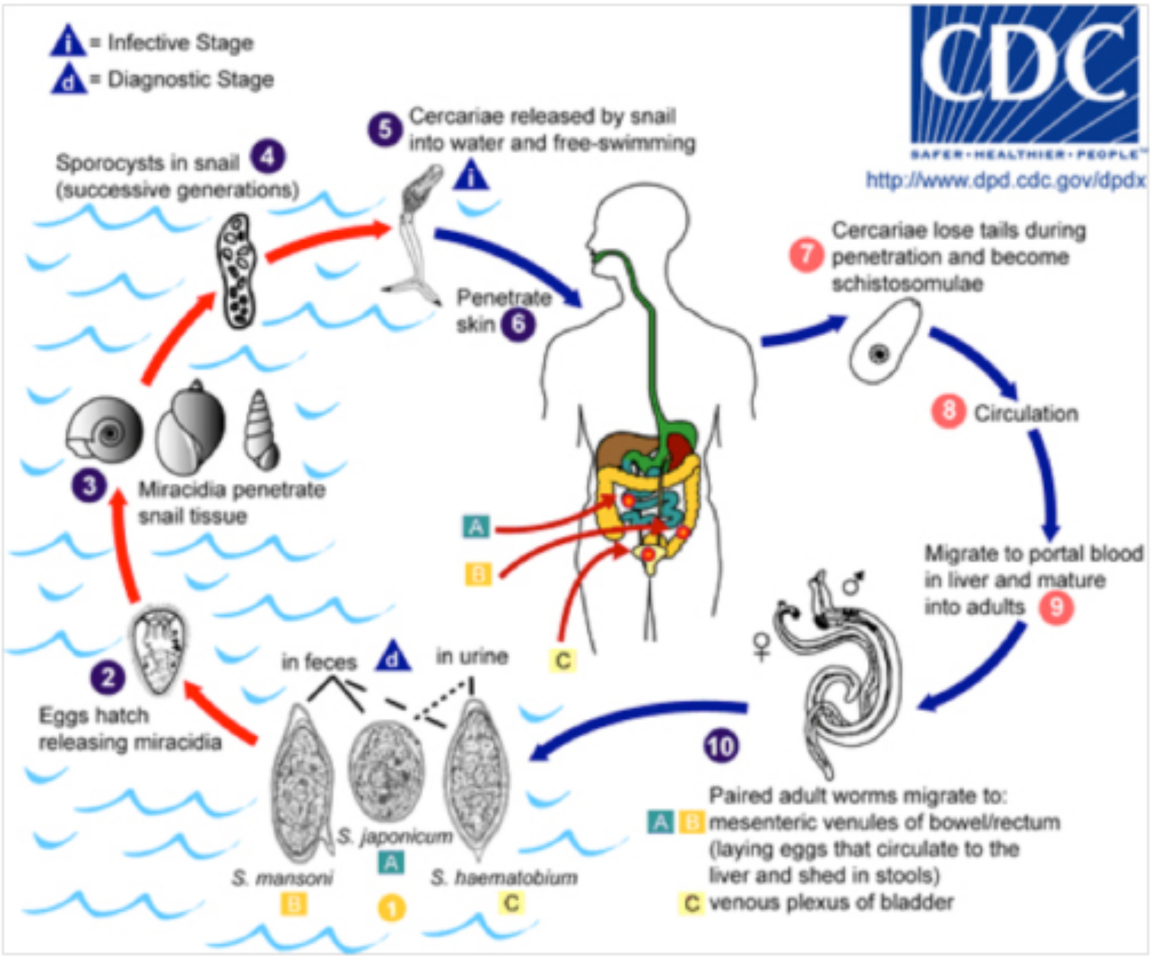

Figure 3. Life cycle of *S. haematobium, S. japonicum,* and *S. mansoni* (Center for Disease Control and Prevention 2010)

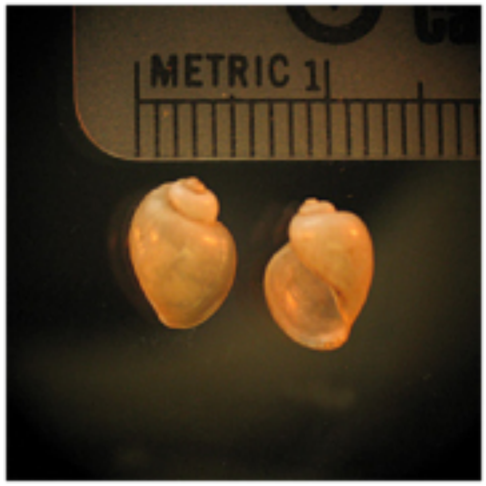

Figure 4. Bulinus snail, intermediate *S. haematobium* host (Center for Disease Control and Prevention 2010)

Miracidium mature into cercariae inside the snail's circulatory system. Cercarial shedding is provoked by light and usually occurs in the middle of the day. The snail can shed the fully developed cercariae at a rate of 1,500 per day for up to 18 days (Coon 2005). "One snail, infected by one miracidium, can shed thousands of cercariae every day for months" (Gryseels *et al*. 2006). Therefore, only a small number of snails can be responsible for infecting many people. Figure 4 shows the size of the intermediate host, the *Bulinus* snail. Once the cercariae are released into the freshwater environment, they have 72 hours to locate a human host via chemotaxis or they will die. Cercariae are tiny free-swimming larvae and seek out the skin of humans who are in contact with infested water during occupational activities (e.g. washing dishes, fetching water for domestic use, or fishing) or leisure and recreational activities (e.g. bathing and swimming) (Fenwick and Utzinger 2008). Children from the ages of 7 to 14, farmers, fishermen, and village women have the highest risk of getting infected because of their interaction with contaminated water (Acha and Szyfres 2001).

Upon finding a host, the highly motile cercariae shed their tails and penetrate unbroken skin through sweat glands or hair follicles (Acha and Szyfres 2001), a process that takes only a few minutes (Fenwick and Utzinger 2008). The cercariae are less than 1 cm in size and would be difficult for an individual to visually detect while in the water (Cook and Zumla 2009). Once inside the human body, they differentiate into the next larval stage, a schistosomula, and take about four days to migrate (Coon 2005) in the blood vessels to the right side of the heart and the lungs (Fenwick and Utzinger 2008). They remain there for about 4 to 8 days (Coon 2005), then exit the lungs and are passed to the left side of the heart, from where they are distributed to all organs proportional to cardiac output and arrive at the liver (Fenwick and Utzinger 2008). Only worms that reach the portal system of the liver mature into adults (Coon 2005). It takes about 4 to 9 weeks from skin penetration until male and female worms have matured in the liver, and they meet and pair up, before migrating once more to their final resting position within the blood vessels around the bladder (Fenwick and Utzinger 2008). While moving through the circulatory system, the worms do not affect other organs in the body, except the bladder and urinary tract. There can be liver damage if eggs are deposited there and granulomas form as an immune response, but this is a rare occurrence.

When the worms reproduce, eggs make tears in the bladder wall while trying to leave the human definitive host to continue the life cycle of infecting the intermediate snail host. This process causes blood to be expelled as a result of the tears in the bladder walls and pieces of the bladder lining can also be present in the urine. Microhematuria is one of the diagnostic testing procedures for the disease and the presence of blood in the urine can be checked by using a dipstick.

Eggs (shown in Figure 5) get released through the urine and, if dispensed into a body of water, can potentially continue the cycle of reinfection. The life span of an adult schistosome is around 3 to 5 years. The theoretical reproduction potential of one schistosome male and female couple is up to 600 billion schistosomes, which has detrimental implications for a community that relies on an infected water source (Gryseels *et al*. 2006).

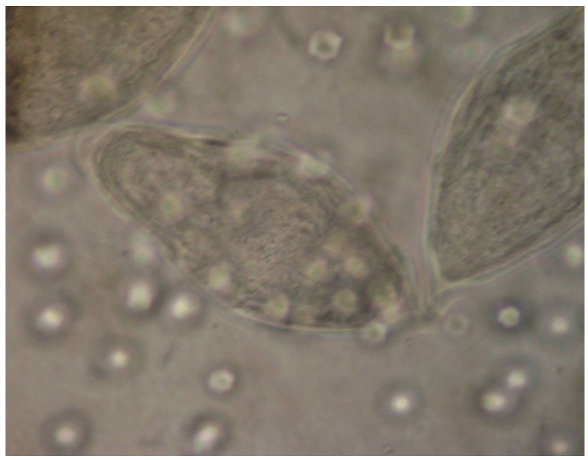

Figure 5. Microscopic view of a schistosome egg observed in the urine sample of a child from Adasawase during 2010

2.3 IMMUNOLOGY OF SCHISTOSOMIASIS

Because schistosomes have developed many methods of down-regulating a human's immune response to their presence, it is difficult for an immune system to eliminate a schistosomiasis infection on its own (Acha and Szyfres 2001). As with many other helminth parasite infections, schistosomes can survive within a human host's body without causing any severe complications or symptoms. The initial phase of infection that provokes a noticeable immune response is elicited when the parasite matures in the liver and when oviposition (the laying and depositing of schistosome eggs in bladder tissue) takes place. Cytokines are secreted when an acute immune response occurs in response to antigens released by the eggs at this stage in the infection (Acha and Szyfres 2001). Another important immune response to a schistosomiasis infection is the development of granulomas due to schistosome eggs trapped in the host's tissues. Tumor necrosis factor α is suspected to be involved in the formation of granulomas (Acha and Szyfres 2001). In the case of *S. haematobium*, granulomas occur in the tissue of the bladder walls. Many methods by which the schistosomes would be capable of down-regulating its host's immune system have been explored, however a definitive mechanism has not been settled upon yet (Jenkins *et al*. 2005). The down-regulation of the immune system makes it easier for the parasite to proliferate within its host; however, it also lessens the pathology associated with a schistosome infection (Murphy *et al*. 2008).

The dominant immune response to a schistosome infection is elicited by CD4 T_H2 cells. The T_H2 cells are activated by dendritic cells presenting worm antigen via an MHC II molecule. T_H2 cells produce many cytokines which are involved in the immune response to a schistosome infection is many different ways. The cytokines IL-4 and IL-13 stimulate the class switching of B cells to IgE antibody production. IgE antibodies are bound to mast cells, which induce inflammation and are involved in allergic responses. IL-3 and IL-9 recruit and activate a specialized population of mucosal mast cells, which are armed with the IgE produced by the class-switched B cells. IL-5 recruits and activates eosinophils, as seen in Figure 6, which are involved in the killing of antibody coated parasites. The first indication of an immune response due to a parasitic infection would be increased levels of eosinophils, mast cells, and IgE antibodies (Murphy *et al*. 2008).

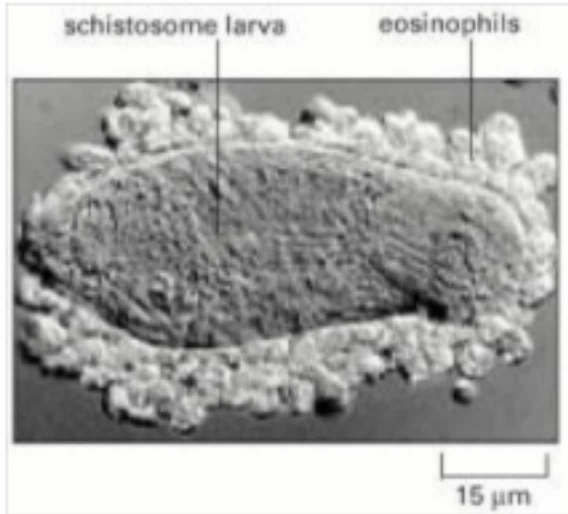

Figure 6. Schistosome larva infiltrated by eosinophils (Alberts *et al*. 2010).

2.4 Clinical symptoms and Diagnosis of Schistosomiasis

There are four main phases of symptomatology related to a schistosomiasis infection. The first phase is associated with the penetration of the cercariae into the host's skin. During this stage, a cutaneous skin allergy to the parasite's products occurs. Petechiae (small spots of bleeding under the skin that may appear purple or brown in color) with edema and pruritus (itchy skin) develops, followed by urticaria (hives), which can become vesicular. This stage typically lasts from 36 hours to 10 days; however, humans do not always have a cutaneous manifestation in response to infection (Acha and Szyfres 2001).

The second phase of the disease occurs when the schistosomula invades the pulmonary capillaries (blood vessels surrounding and in the lungs). This can lead to pneumonitis, coughing, asthma-like crises, and eosinophilic infiltration. These symptoms typically only happen in massive infections (Acha and Szyfres 2001).

The third phase of the infection correlates to with the parasite maturation in the liver and with oviposition in the bladder. This does not normally produce damage to the tissues or clinical presentations. In massive infections, fever, diarrhea, abdominal pain, urticaria, and lethargy will occur (Acha and Szyfres 2001). This stage takes place one to two months after the initial infection, and at this point the human host begins to display signs of a full-blown immune response to a parasitic disease. Hepatitis and enlargement of the liver, spleen, and lymph nodes may occur also as an indication of the body attempting to wage war against the parasite invader (Acha and Szyfres 2001). Some individuals infected by *Schistosomiasis haematobium* may develop pulmonary hypertension as well but this symptom is rare. These indications of the immune system at work last one to three months; however, some individuals will not experience any of these clinical signs (Temple 2004).

The fourth and final stage of the disease is related to the deposition of eggs in the bladder tissue, or oviposition. This is called the "chronic" or "granulatomous phase," because granulomas are formed around the eggs that are embedded in the bladder epithelium. Once the granulomas become abundant, they are capable of converging and invading a vital part of the organ (Acha and Szyfres 2001). This can become detrimental to normal bladder health and function.

Months to years after initial infection, infected individuals will develop the archetypal *S. haematobium* symptoms. At this point of infection, the schistosome has taken up residence in the human host's bladder and begins to cause urinary problems. The human host may experience dysuria (painful urination), terminal hematuria (blood in urine), frequent urination, recurrent urinary infections, suprapubic pain, and urethral or ureter obstruction which leads to the inability to urinate. In some cases, these symptoms can lead to kidney disease and some men can experience elephantiasis of the penis (Temple 2004).

If these symptoms are left untreated for an extended period of time, serious complications may arise. Bacterial urinary tract infections are common due to the disruption of normal, healthy urination. The schistosomes attach to the transitional epithelium lining of the bladder and cause irritation and bleeding. The irritation may cause cysts, tubercles, polyps, ulcers, sandy patches, cystitis (bladder inflammation), and/or leukoplakia (hardening of the bladder walls due to keratinization) to develop in the human host's bladder (Zinck and Trafford 1956). The irritation to the bladder can lead to calcification of the epithelium. The most serious complication that can develop from a chronic schistosomiasis infection is squamous cell carcinoma of the bladder (Temple 2004). Figure 7 shows a tumor, which was removed from the bladder of a person infected with *S. haematobium*.

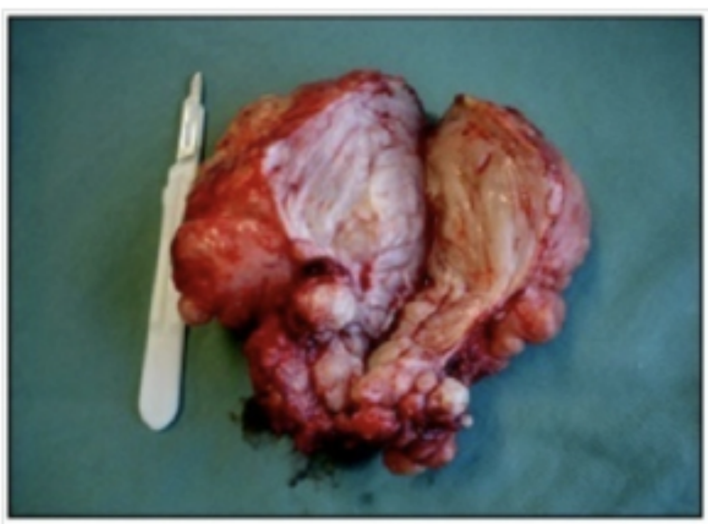

Figure 7. Squamous cell carcinoma tumor excised from the bladder of an individual with *S. haematobium* (Casella *et al*. 2009) .

The most common way of diagnosing urinary schistosomiasis is through microscopic detection of schistosomal eggs in the urine. Because eggs can be present in very small quantities, multiple screenings for eggs in the urine are needed. The schistosomal eggs can be filtered from the urine sample through the use of a Nucleopore® membrane (Center for Disease Control and Prevention 2010). A second method of diagnosing schistosomiasis is through urinalysis to detect blood in the urine (Temple 2004). The presence of blood in the urine is called hematuria and can be detected either macroscopically or through the use of urine dipstick tests. However, other urinary problems not related to a schistosomiasis infection can also result in blood in the urine. Third, tissue biopsy of the bladder tissue can confirm a *S. haematobium* infection through the detection of eggs and observation of damage to the bladder epithelium (Center for Disease Control and Prevention 2010). Fourth, blood work to check for elevated levels of eosinophils, which indicate the presence of a parasitic infection, can also indicate a schistosomiasis infection (Temple 2004).

2.5 SCHISTOSOMIASIS AND HIV/AIDS

Helminthic diseases are prevalent in the same geographical locations as HIV/AIDS, tuberculosis and malaria (Hotez *et al*. 2007). These three diseases are known as the "Big Three" as they are the three biggest health threats globally and in particular in Sub-Saharan Africa. Neglected tropical diseases, such as schistosomiasis, have been shown to make individuals more susceptible to contracting the "Big Three" (Hotez *et al*. 2007). Figure 8 shows two maps of Africa. The map on the left depicts prevalence of *S. haematobium* on the continent and the map on the right depicts the prevalence of HIV/AIDS. These two maps show the overlap of countries that are endemic for *S. haematobium* and HIV/AIDS.

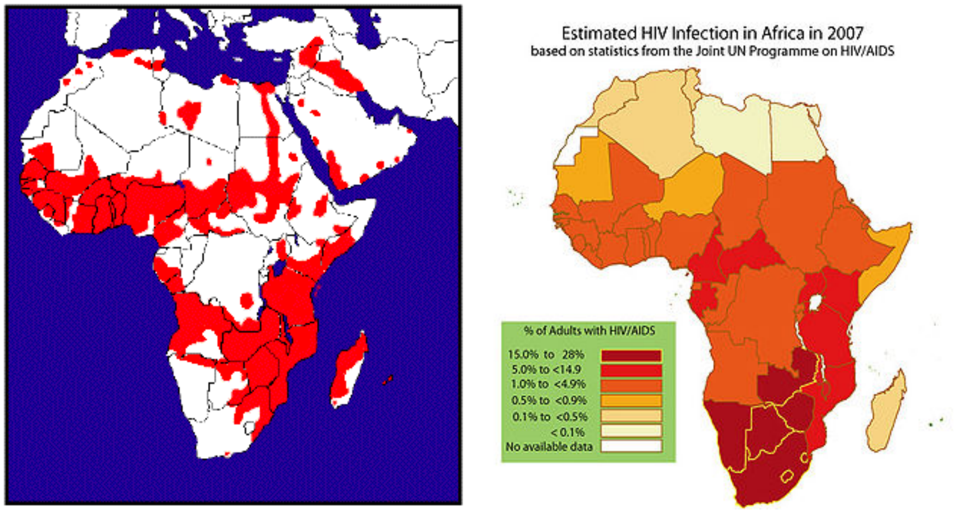

Figure 8. Maps of Africa showing the prevalence of *S. haematobium* (left) (Temple 2004) and the prevalence of HIV/AIDS (right) (Paulson 2010) .

Both males and females with urinary schistosomiasis can develop genital sores and lesions which can facilitate the transmission of HIV; however, females tend to be the most susceptible to contracting HIV when they are also infected with *S. haematobium* (Hotez *et al*. 2007). Because the male urethra is the exit route for both urine and semen, and schistosomal eggs are excreted through an individual's urine, it is also possible for men to release schistosomal eggs in their semen during intercourse (Kosinski unpublished). In a study performed in Zimbabwe in 2006, it was discovered that women over 35 years old who had urinary schistosomiasis were more than twice as likely to contract HIV as women without urinary schistosomiasis (Kjetland 2006). Peter Hotez, one of the leading experts in the field of neglected tropical diseases, has postulated that the control of endemic neglected tropical diseases, specifically *S. haematobium*, in Africa may help in reducing the spread and prevalence of HIV/AIDS (Hotez *et al*. 2007). Although, schistosomiasis may seem less threatening than many of the other endemic diseases in Sub-Saharan Africa, its control may be a viable option as a method of lowering the HIV/AIDS prevalence in the continent.

2.6 Methods of Schistosomiasis Control

Acha and Szyfres (2001) outline six main methods of schistosomiasis control as follows:

1. Testing and treatment of infected patients
2. Selective and mass treatment with Praziquantel
3. Improving water supply and access to latrines
4. Control of the intermediate hosts (snails)
5. Changing of environment
6. Health education

Each of these methods of schistosomiasis control is explored in depth in the following sections of this report.

2.6.1 Testing and Treatment of Infected Individuals

The most important step in schistosomiasis control is testing individuals in an area that is suspected to be endemic and determining the prevalence rate based on a sample of the population. As described in section 2.4, there are multiple options for testing for a *S. haematobium* infection. As mentioned previously, schistosomiasis is diagnosed through the presence of blood in the urine (macrohematuria or microhematuria), the presence of schistosome eggs in the urine (observed microscopically), a tissue biopsy of the bladder, or a blood test for increased levels of eosinophils. The most accurate and easy way of testing for a schistosomiasis infection however, is by testing urine samples for blood and schistosome eggs.

Once a prevalence rate is determined, the next step in control is treatment. Much controversy had arisen over whether it is best to mass treat areas where *S. haematobium* is endemic or to selectively treat the infected individuals. There are pros and cons to both approaches and it depends on the specific situation. Praziquantel is the medication used to treat schistosomiasis infections from all species. The dosage given for a schistosome infection is 40 mg/kg of body weight (Tchuente *et al*. 2004). Many other antischistosomal medications have been experimented with in the past century, but most are less effective, more expensive, and less available than Praziquantel. Most other antischistosomal drugs have more serious side effects and are less effective against multiple strains of schistosomiasis than Praziquantel (Webbe 1987). Studies have shown the artemisinin derivatives can be effective against larval stages of schistosomiasis but this is more expensive and difficult to get in African countries (Kosinski unpublished). Praziquantel has been shown to be less effective 4 weeks post infection but highly effective 8 to 12 weeks post infection. Praziquantel is most effective against the adult stage of the parasite while the immature schistosomes (2-4 weeks old) are less susceptible to the drug (Tchuente *et al*. 2004). Some evidence has been found that suggests certain strain of schistosomiasis can be tolerant of Praziquantel treatment and certain populations of people in endemic areas of Africa have showed resistance to the drug as well (Fallon *et al*. 1996). The development of an antischistosomal vaccine will need to be explored if the issue of Praziquantel resistance increases (Webbe 1987). A single dose of Praziquantel has been shown to be more effective than multiple doses, generating a cure rate greater than 83% and an egg reduction rate of greater than 98%. However, schistosome eggs can continue to be excreted through the urine of an infected individual even after treatment (Tchuente *et al*. 2004).

Side effects of Praziquantel can include nausea, vomiting, and abdominal pain, but these are rare and many times can be avoided if administered with food (Kosinski unpublished). Interestingly, when Praziquantel is synthesized, it is a racemic mixture of levo- and dextrorotatory isomers. Levorotatory Praziquantel is the isomer that has the schistosomicidal properties while the dextrorotatory isomer is ineffective and is the part of the compound that contributes to all the side effects of Praziquantel (Ching *et al*. 1993). If an inexpensive method of separating the two isomers were developed so that the compound was made from purely levorotatory Praziquantel, the drug would be more effective and come with fewer potential side effects (Kosinski unpublished).

The World Health Organization (WHO) suggests selective treatment of infected individuals in areas with lower endemicity (Kosinski unpublished). Mass treatment can be effective in areas where the endemicity is higher and where the human reservoir is large. Selective treatment can be seen as less effective since it only takes one infected individual to continue the life cycle. Due to continued contact with infected water, a yearly treatment program must be put in place to treat the worm burdens individuals may have developed within the year after being treated. A yearly mass treatment program within a school system requires the cooperation of the schools, help from a health care facility to administer the medication, and some source of money which will go towards paying for the Praziquantel and healthcare workers. One dose of Praziquantel (3 pills) is estimated to cost about USD $0.50 (Kosinski unpublished).

2.6.2 Improving Water Supply and Access to Latrines

Improving water supply and sanitary excreta disposal are two control initiatives that require significant financial resources and community commitment (Acha and Szyfres 2001). Providing safe and sanitary latrines can prevent infected excreta from reaching areas where it can then re-infect others (Sandbach 1975). This also raises the quality of the water where people are bathing and washing.

When access to uninfected water is improved, community members are no longer forced to collect water in areas that are infected. This is classified as a socio-economic issue and endemic countries often time are not in the position to improve their situation. Improved access to water can include building more community handpumps, or platforms that help avoid the need to enter the water.

2.6.3 Control of Intermediate Hosts (snails)

The type of habitat, vegetation, seasonal rain variation, and changes in water characteristics determine what snails lay eggs in the water. Each schistosoma species prefers different habitats which makes control of the host a difficult process (Patz *et al*. 2000).

By control of the intermediate host, spread of schistosomiasis can be reduced. The first control method is by chemical intervention. Copper sulfate can be used, although an excess amount of silt reduces its molluscicidal effect (Van Der Schalie 1958). The cost of copper sulfate has been a limiting factor in the widespread use of the chemical as a molluscide. In addition, the amount of man-days required to clear vegetation and prepare the site prior to application of the chemical adds a considerable amount to the total cost of the project (Van Der Schalie 1958).

The second snail control method is environmental modification to eliminate vector snails (Chitsulo *et al*. 2000). This type of control was implemented in Morocco in the mid-1990's. First, a mass treatment program was used in 1995 to treat all exposed village members excluding children under two and women who were pregnant. After four months, there were no reported cases of schistosomiasis; however, after ten months, the Ministry of Health determined that the Akka Oasis was still a place where transmission of urinary schistosomiasis occurs. In May 1997 regular clearing of vegetation around the infected body of water was started. It was determined during a case study that this was a low cost and environmentally friendly option for controlling the host snail *B. truncates* (Boelee and Laamrani 2004).

2.6.4 Change of Environment

As described in section 2.6.3, changes in the environment can help reduce spread of schistosomiasis. However, changes of environment also can foster schistosomiasis spread. Building dams can increase urinary schistosomiasis, but decrease intestinal schistosomiasis in those areas (Chitsulo *et al*. 2000). In 1965 a dam was constructed in Ghana to provide electricity for the aluminum industry. The creation of Volta lake behind the dam resulted in an increased growth of aquatic vegetation. The habitat change, along with the slowed river flow rate produced an increase in *B. truncatus* snails in the area. In Kitare, a town adjacent to the Volta lake, urinary schistosomiasis prevalence went from 0% in 1968 to almost 100% prevalence in 1992 (Zakhary 1997).

2.6.5 Health Education

Since school age children are a group that is highly infected by schistosomiasis, targeting them would be effective in decreasing prevalence rates. Health education would serve as an informative method of controlling the disease. Because it can improve knowledge about the nature of a parasitic infection and the risk of acquiring/transmitting an infection. Education has the potential to change behavior, and can help create an active awareness among people in endemic areas that contributes to sustainability of control programs and ownership of these programs (Kosinski unpublished).

Health education efforts should be directed in three ways: earlier diagnosis and treatment, community involvement in designing and implementing control programs using local resources, and behavioral changes that reduce the risk of contamination and exposure to water bodies harboring intermediate snail host (Kloos 1995). In Adasawase, mass treatment of Praziquantel, building the alterative water recreating facility for the town with community members, and observing river activity to understand behavioral patterns of the children have been carried out to address the three guidelines mentioned previously. But a thorough education initiative has yet to be implemented for the Adasawase community. Integrated control measures that include health education in conjunction with chemotherapy, focal intermediate host snail control, water supply, and sanitation could allow sustainable schistosomiasis control to be achieved (Utzinger 2003).

2.7 PAST *S. HAEMATOBIUM* WORK IN ADASAWASE

As previously stated, approximately 17.6 million people in Ghana were infected with schistosomiasis in 2008, which is about 73% of the total population. Due to the high prevalence of *S. haematobium* in Ghana and the relatively peaceful disposition of the country, towns were selected within the Atiwa district of the Eastern region of Ghana by Tufts University to be project sites for *S. haematobium* research in conjunction with Noguchi Memorial Institute for Medical Research at the University of Ghana. After testing various towns for prevalence rates to assess where control efforts would be beneficial and establishing relationships with the community to being research, Karen Kosinski, a PhD student at Tufts University, started working in the rural village of Adasawase in the Eastern Region of Ghana in 2007.

Adasawase is a small rural town off the main road that connects Accra, the capital of Ghana, and Kumasi, the second largest city in Ghana. Initial diagnostic tests on the school children through urine sampling showed that 49.8% were infected with schistosomiasis. Tini River was identified as the primary source for *S. haematobium* infection in the town. Tini River is a central water body that is used by many of the townspeople on a daily basis. Water is fetched from the river and used for clothes washing, cooking, bathing, and possibly even drunk. Many of the children in town also use the river as a recreational place. This river is slow moving and has become the habitat for *Bulinus* snails, the intermediate host of *Schistosomiasis haematobium*.

Kosinski recognized that continued daily contact with the cercariae-infested water of Tini River led to a high prevalence of *S. haematobium* in the town and plans for an alternative recreation area began.

The design for the alternative recreating facility was a collaborative effort among a team of undergraduate and graduate students, engineering and health professionals, and local community members. The goal was to create a structure that met the community needs, was economically appropriate, and attractive to users (Kosinski unpublished). Ghanaian culture, traditional beliefs, and superstitions were taken into consideration when schistosomiasis control methods were implemented as to not insult members of the community and to facilitate community involvement.

The location of the alternative recreation area was near a plantain orchard that was in close proximity to the town's two hand pumps, which are used for fetching water from a natural aquifer. From a behavioral perspective, this was an ideal location because children would have to pass the swimming pool on their way to the river. And hopefully, the swimming pool would be more appealing since it was closer than the river and if children saw their friends at the pool they would be more inclined to go there instead.

Construction began on the swimming pool in the summer of 2008 and was completed in August of 2009. In order establish ownership of the pool to the town, Kosinski emphasized having the building process be a cooperative effort between her research team and the community, which would also assist with future maintenance. Materials used were found locally for sustainability and reproducibility, if neighboring towns wanted to employ this model.

Kosinski continued to collect data on infection rates during the construction process and also mass treated the children with Praziquantel. In the summer of 2010, reinfection rates were determined for comparison to those prior to the implementation of the alternative recreating facility.

Kosinski's control program addressed three of the six control methods mentioned by Acha and Szyfres (2001): testing and treatment of infected patients, selective and mass treatment with Praziquantel, and changing of environment by building the swimming pool. Controlling the intermediate host was not pursued since the Adasawase community decided that the use of chemicals to eliminate them from Tini River would be detrimental to the environment. Therefore, the last two methods that were yet to be implemented were creating an educational initiative and improving water supply.

Chapter 3: Materials and Methods

Most work was conducted while the team was in Ghana from June 5, 2010 to July 31, 2010. The goals of this project were to design and construct a filtration system for the pool, test for schistosomiasis prevalence using sampling, assess knowledge of schistosomiasis, and develop an education initiative for the village of Adasawase.

3.1 Water Recreation Center

In 2008-09, a water recreation center was constructed in Adasawase by Karen Kosinski. After Kosinski left the Adasawase area, the villagers were responsible for the maintenance of the pool. The pool had a shallow end (8’x17’x1’) that held a total of 1017 gallons of water, and a deep end (14’x17’x4’) that held a total of 7121 gallons of water. A polytank installed in 2009 held water that was used to fill the pool. The water in the polytank included collected rainwater off of one of the construction team’s homes. A pipe from the polytank was connected to a pipe in the wall of the shallow end for filling, which in addition to the nearby handpumps was done on an as-needed basis. The pool also included a drain pipe, which discharged water to the natural drainage ditch nearby. The intent of the drain pipe was to allow for complete drainage of the pool water on an as-needed basis remove sediment and other potential contaminants from the pool. Upon arriving to the pool on June 16, 2010, there was very little water in the pool, and the pool was visibly dirty.

On June 21, 2010, a meeting took place with the head mason, who previously worked on the construction of the pool, to assess the status of the water recreation center. The questions asked were:

1. What are the main problems with the pool?
2. Has the pool been consistently getting filled?
3. What steps are needed to get this project under way?
4. What needs to get fixed?

From the meeting, the steps needed to open the pool were determined. The main problem appeared to be that the pool was not draining properly. Upon inspection of the pool during the meeting it was determined that the pool would take 3-4 hours to drain a couple of feet. Because the pool could not be drained quickly, the pool water appeared turbid. This deterred people from using the pool because the water was perceived as dirty and having the potential to get people sick. According to the mason, the drainage issue was caused by children throwing rocks down the drain, causing it to clog.

In order to get the project underway, on June 23, 2010, a portion of the pipe was dug up. The materials used were shovels and a pickaxe. Upon digging the pipe up, it was found that the PVC had collapsed under the weight of the earth. Because the pipe was damaged, new hard PVC was purchased on June 26. The pipe was fully dug up and replaced on June 28.

The next task was cleaning the pool. The team used five gallon water buckets and small scrub brushes to remove dirt caked on the bottom of the pool (shown in Figure 9).

Figure 9. Cleaning the pool with scrub brushes

After cleaning the pool, the team used the hand pump to pump water into the shallow end of the pool. The hand pump was fitted with special pipe connection piece, designed by the civil engineer who built the pool, onto the mouth of the pump. The connection was attached to a pipe that ran underground and discharged water through an opening in the wall of the shallow end of the pool. As a result of the slow flow rate from the pump and the use of the water for cleaning during the filling process, it would take approximately eight hours to fill the ~1100 gallon shallow end.

After the pool was prepared for use, the filtration unit design commenced. The criteria used to determine placement of the filter were:

- Height on site
- Material constraints (i.e. length of piping needed, and number of bends needed)
- Drainage (proximity to drainage ditch for backwashing)
- Proximity to pool

- Susceptibility to damage
- Work to complete

After assessing these criteria, a final design for the system was developed (see Results). The team traveled to Koforidua on July 5 to price potential materials. This preliminary trip was used to determine material available and costs. A rock quarry was visited to determine prices and options for filter media. Unfortunately, the quarry only would sell a truckload as a minimum, which was cost prohibitive. The team took a second trip to Koforidua on July 6 to purchase the Rambo-070 Polytank and the PVC parts.

Because the filter media could not be bought new from the quarry, the team hired a community member to go to the local rock quarry to collect two wheelbarrows full of 2-3 inch rocks to be used for the bottom layer of the upflow roughing filter. The smaller aggregate, used for the upper layers of the filter, came from the leftover materials used in the pool construction. Because this aggregate had been left out all year, it had accumulated a large amount of organic debris and dirt. The team, as shown in Figure 10, used a five gallon bucket to collect water for cleaning the aggregate. The water was poured over a laundry basket filled with small aggregate and the dirty water exited the bottom of the basket.

Figure 10. Collecting water for cleaning filter media

The filtration system was completed and began operation on July 27, 2010 and the team left Adasawase on July 28, 2010.

3.2 URINE SAMPLING

Urine sampling was conducted to quantify infection prevalence. Tests for microhematuria, the presence of blood in the urine, were performed using a dip stick method and eggs were analyzed by filtering the urine and using microscopy to identify them. School children in Adasawase were tested for schistosomiasis infection by two methods as described in the following sections. This methods and materials section is adapted from Kosinski (Kosinski unpublished).

3.2.1 Study Population

All children that attend any of the three schools (D/A Junior High School, Methodist Primary School, and Presbyterian Primary School) in Adasawase were invited to participate in this study. Recruiting took place in May of 2010 by Kosinski and the cultural interpreter through the local school systems and town meetings. In total, 585 school children from 5 to 22 years of age participated and four samples were collected from each participant from June 14-July 16, 2010.

3.2.2 Consent: Institutional Review Board

This study was approved by the Institutional Review Boards (IRBs) of Tufts University and the Noguchi Memorial Institute for Medical Research (NMIMR). Verbal consent was obtained from each child who participated. Permission to carry out the study was also obtained from the Chief of Adasawase and from the head of each school; these same individuals communicated the nature of the study to the larger community.

3.2.3 Urine Collection and processing

Each child in this study was asked to provide a urine sample on four different dates. Collection occurred between 1000 and 1400 hours. Schools were visited during recess periods to minimize disruption to their academic schedules.

Children were provided with conical plastic tubes (50 ml) for urine collection. After sample collection two diagnostic tests performed on each sample. First, urine was tested for microhematuria via a semi-quantitative dipstick test (Accu-Tell Urinalysis Reagent Strips). The dipstick test was performed by shaking the urine containers and reading the reagent stick for the presence and amount of blood as seen in Figure 11. Once a sample was tested, the dipstick was set aside for 2 to 4 minutes for color development.

Figure 11. Testing a dipstick

The dipstick tested urine using nine parameters and each one had its own testing square on the stick: glucose, protein, pH, blood, ketone, nitrite, urobilinogen, bilirubin, and specific gravity. Results were only recorded for the presence of blood as negative (-), trace (+/-), 1+, 2+, and 3+ based on the key provided on the dipstick container. The color key for blood was bright orange and presence of blood in a sample was indicated by blue dots appearing on the orange square; the greater presence of blood in a sample, the more blue dots would appear.

The second diagnostic test was for the presence of eggs by filtration. Each sample was shaken and drawn into a plastic syringe. The 10 ml sample was filtered through a Nucelopore® membrane (25 mm diameter, 12.0 μm pores) as seen in Figure 12. The membranes were transferred using forceps onto microscope slides for examination. A certified laboratory technician from NMIMR read all slides within four weeks of sample processing. The technician was blinded as to the identities of study participants and to the results of each participant's previous screening(s).

Figure 12. Nucleopore® membrane holder used for urine filtration (Optics Planet 2010).

3.2.4 DATA ENTRY

School records and attendance sheets were reviewed by Kosinski and information on the student's names and age were imputed in an Excel file for those that were going to participate in the study. Each child was also given a code that protected his/her identity, which complies with IRB standards. The code had initials for one of the three schools in Adasawase and then a number.

When collecting urine samples, a binary system of recording was used and compiled in the Excel file. If a child gave a sample, "1" was recorded as present and , if not a "0" was entered.

Results from the dipstick test and egg counts were recorded in notebooks and transferred into the running electronic file as well. They were reviewed twice to account for errors that could occur while transferring.

3.3 Knowledge Attitude and Practice Survey

To determine the basic Bilharzia (name that most Ghanaians associate with a *S. haematobium* infection) knowledge that schoolchildren in Adasawase have, the MQP team put together a Knowledge, Attitudes, and Practices survey. A KAP survey, used by Kosinski in past years, was utilized to generate questions for the survey and to determine how to organize the questions. Institutional Review Board approval had been received for the KAP survey conducted in past years; therefore, additional IRB approval was not sought. In order to make the survey engaging for the schoolchildren, a Microsoft PowerPoint presentation was used to present the survey.

The survey was divided into five sections and thirty questions formulated about the use of Tini River, use of the pool, knowledge of Bilharzia, and overall disease knowledge (See Appendix C for survey). The first section, consisting of five questions, focused on the children's interactions with Tini River to determine their level of risk of infection. The second section also consisted of five questions and asked about the children's sanitation and hygiene practices. This section explored the children's bathroom habits and compared their self-reporting with what they report they see other people in their town doing. The third section was entitled "Knowledge of Disease" and determines whether or not the children have a basic knowledge of Bilharzia. The fourth section is entitled "Attitudes and Practices" and asked the children what they are taught about in school about health and disease, what they do when they are sick, and whether or not they have noticed Bilharzia symptoms in themselves. The last section asked the children about their use of the swimming pool. This section was intended to gather information about what can be improved at the pool site and to see which children are using the pool to recreate.

Eye-catching colors and visuals were used in the PowerPoint presentation to engage the children while they were being surveyed and help bridge the language barrier. Although native interpreters were used to translate each survey, the MQP team decided that the use of photographs taken in Adasawase would aid in gathering accurate information in case the children did not understand the question being asked of them. Although many children may not know the proper name for the borehole or the name of the river, it was assumed that when they were shown a picture of the place or activity being asked about, they would recognize it and be able to answer more accurately. One Sunday afternoon, five children from the cultural interpreter's household were taken to Adasawase to help the MQP team with the survey photo shoot. The children were photographed performing different tasks or practices that were asked about in the survey, such as collecting rainwater or pumping water at the borehole.

The regional language used in Adasawase in called Twi. The MQP team had considered translating the entire PowerPoint presentation to Twi. However, this was deemed unnecessary because most schoolchildren learn to write in English in school and translators were available during the survey administration. When asking about the use of the river and swimming pool, the Twi words for the days of the week were used. When asking the children if they knew what color the urine of an individual infected with Bilharzia would be, five circles appeared on the screen that were red, green, purple, blue, or yellow. The child was asked to physically point to the color the urine would appear if a person had Bilharzia.

Several open-ended questions were included in the survey to see what answers the children would produce, without being prompted by multiple choices. Question 10 asked, "What do you see people doing in your town that you think is a health risk?" in order to see what schoolchildren perceive as important health risks within their community. Question 18 asked, “What have you learned from your teachers at school about health and diseases?” to determine what the teachers considered important health and disease topics and what health education information the children retained from their classes.

Surveys were conducted at all three of the schools in Adasawase (Methodist Primary, Presbyterian Primary, and Junior High School) between July 8 and July 16. Three native, Twi-speaking Ghanaians were employed as translators to conduct the surveys in the native language of the children. Conducting the surveys in their primary spoken language helped reduce confusion and minimize miscommunication to yield the most accurate results. Surveys were conducted during school hours, normally between 8:30AM and 1:30PM, either while the children were on break or while classes were in session, by excusing children from class one at a time to cause the least disturbance to their lessons.

Since it was determined from surveying the schoolchildren that the majority of them got their information on Bilharzia from their school teachers, the MQP team gathered information from the teachers as well. An abridged version of the survey was created and data were obtained from teachers at each of the three schools in town through focus groups. The cultural interpreter noted that an incentive would be needed in order to get the teachers to participate, so meat pies and soda were purchased and distributed while conducting the focus groups. The teachers were asked ten questions that tested the teachers’ knowledge of Bilharzia and inquired about what health topics they teach in their classrooms. The focus group questions for the teachers are shown in Appendix D.

3.4 Bilharzia Health Education

After collecting the data from the KAP surveys and focus groups, it became apparent that there were many misconceptions about symptoms of Bilharzia, transmission, and the life cycle of

S. haematobium. These misconceptions began with the teachers who spread their knowledge of the disease to their students.

To address these issues, the MQP team held an informational session with all the teachers of the Adasawase school system. The cultural interpreter had contacted the schools the week before, offering each school an opportunity to have the MQP team conduct an informational session on Bilharzia. The headmasters of all three schools decided to have the MQP team give the informational session once for all the teachers in Adasawase. The meeting was organized by the superintendent of the Adasawase school system and held on July 23.

The talk was divided in to three sections, and each MQP team member led one of the sections. The talk began with a brief introduction of the MQP team and the project objectives. Then, the six control methods for Bilharzia were listed. Next the MQP team explained the schistosome parasite and life cycle, and drew out the life cycle on the chalkboard as a visual aid. In the second section, the symptoms of Bilharzia were described as well as treatment options. Lastly, three of the Bilharzia control methods were discussed. The MQP team also corrected the misconceptions about Bilharzia discovered during the KAP survey and teacher focus groups. About 15 minutes at the end of the presentation were spent answering questions from the teachers.

At the Bilharzia informational session, the MQP team passed out two handouts as visual aids. One handout had a depiction of the *S. haematobium* life cycle (shown in Figure 13) which shows a young boy urinating in the river, releasing schistosome eggs into the water. Once the eggs hatch in to miracidium, they penetrate the skin of the snail and use the snail as an intermediate host. Once they have matured in the snail they leave the snail and are shown in the figure infecting a boy swimming or another boy who is fishing in the river. The life cycle then continues when those boys return to the river and urinate in the water.

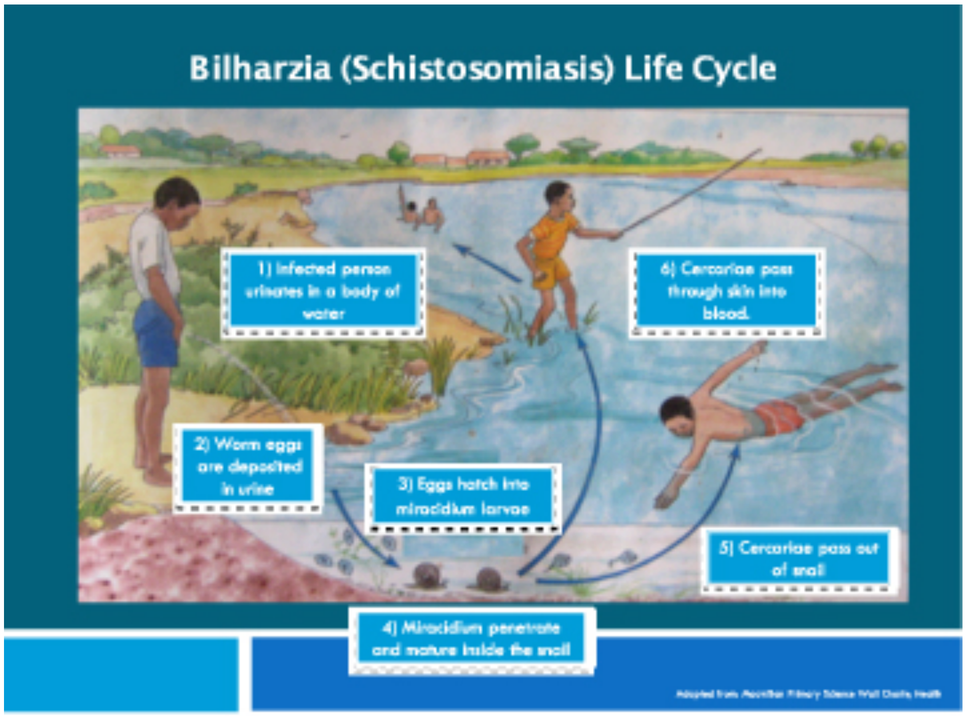

Figure 13. Bilharzia educational handout #1 (Macmillian Primary Science Wallcharts)

The second handout (shown in Figure 14) used during the informational session consisted of four pictures illustrating different aspects of a Bilharzia infection. The first picture in the upper left hand corner shows the intermediate host *of S. haematobium*, the *Bulinus* snail. The snail is shown below a ruler to give the viewer an idea of size of the host (less than 1 cm). The upper right hand picture shows a male schistosome mating with a female schistosome and reports that the male is 10-15 mm in length while the female is 20 mm in length. The lower left hand picture shows the microscopic view of a schistosome egg at 400X magnification, found in 2010 in the urine sample of an Adasawase student by our lab technician. And lastly the lower right hand picture shows three macrohematuria urine samples from previous years.

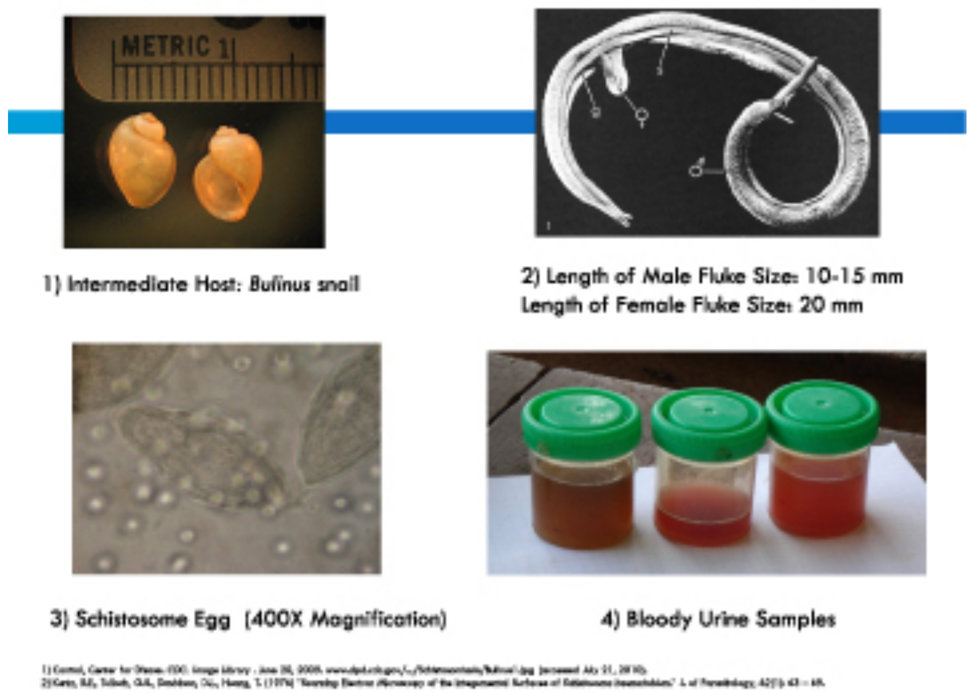

Figure 14. Bilharzia pictorial handout #2

Three copies of each handout were printed and laminated for use during the informational session. After the presentation a set of handouts was given to each of the schools headmasters for use as teaching aids in the future.

The MQP team also compiled a more detailed informational packet on Bilharzia which the teachers of Adasawase could use as a curriculum to teach about the disease. Research completed for the background of the MQP report was used, along with additional research on specific misconceptions about the disease. This informational packet was completed in

September 2010. Printed copies were sent to the cultural interpreter, for delivery to the Adasawase schools.

CHAPTER 4: RESULTS

The team built a filtration system for the water recreation center, collected urine samples for epidemiology data, surveyed children on their knowledge, attitudes and practices (KAP) and piloted a health initiative with local schoolteachers. The following sections present the results of the different parts of the project done in Adasawase, Ghana.

4.1 FILTER PLACEMENT

The filtration setup chosen was a two tank gravity system (Figure 15). The first tank was a holding tank that the schoolchildren would fill using buckets of water. This tank connected to the bottom of the second tank that acted as an upflow roughing filter. Filtered water exited the top of tank 2 through a 1 inch PVC, went down the terracing and up over the wall of the pool, reaching the opposite end of the pool (shown in Figure 16). The clean water discharged from this pipe into both sides of the pool creating a visual and tactile reward for the children to put dirty water into the filtration system. Kosinski (2010) believed this “incentive” would be what helped make the filter work.

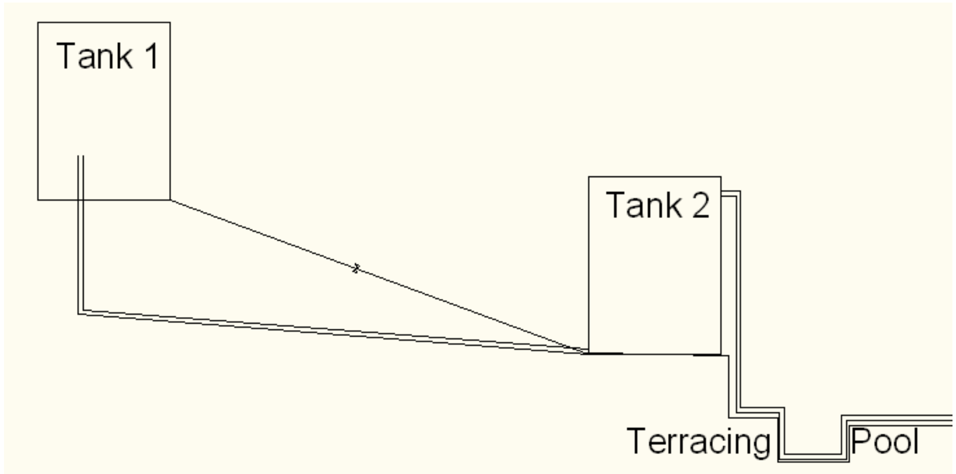

Figure 15. Filtration system setup (tank 1: holding/settling; tank 2: roughing filter)

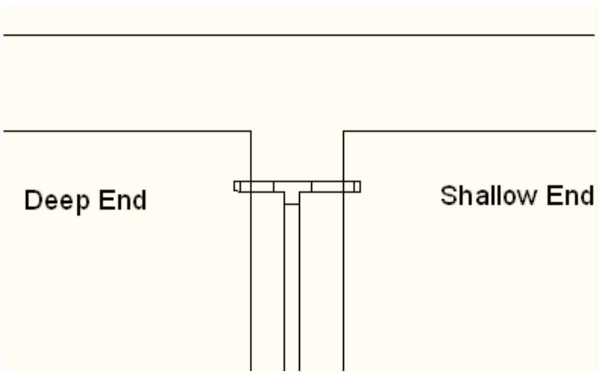

Figure 16. Incentive for children to use filter (left: diagram, right: actual)

Four options were considered for placement of the filtration system. The options were ranked positive to negative based upon a set of criteria as shown in Table 2. The height of each location relative to the pool elevation was ranked based on the amount of head the system would generate. A positive ranking indicates a high filter elevation such that the filter could operate as a gravity flow system, requiring no pumping. Material needs included two factors: length of piping that would be needed and the number of bends. A high number of bends would decrease the available head as well as increase costs. The drainage criterion was based upon the ease for backwash water to be diverted to the natural drainage system. Proximity to the pool was based on material needs and the distance schoolchildren would need to walk to use the filter. Although having a positive (close) proximity was important, it was necessary that the filtration system placement not be susceptible to damage. This was based on two criteria, low human activity in the area to minimize the risk of items getting broken, and placement far enough from rainwater runoff so that erosion did not damage the system. Since the team did not have the opportunity to do extensive observations of the children and their interactions with the pool, this criterion was ranked from discussions with the construction workers, the cultural translator, and Kosinski. Lastly, the amount of work necessary to complete the entire project was a moderately important factor. If there was a lot of preparation work necessary, the project could be delayed.

Table 2. Filtration system placement criteria matrix

Placement	Criteria						Overall Ranking
	Height relative to pool	Material needs	Drainage	Proximity	Susceptibility to damage	Work to complete	
1- latrine side	Positive	Neutral	Positive	Positive	Neutral	Negative	Neutral-Positive
2- near rain water tank	Positive	Negative	Negative	Negative	Negative	Negative	Negative
3- by fence closest to road	Negative	Negative	Positive	Neutral	Positive	Neutral	Neutral
4- split loca-tion	Positive	Neutral	Neutral	Neutral	Positive	Neutral	Neutral-Positive

The first location (Figure 17, number 1) for placement of the filter setup was on the latrine side of the pool. The area would need to be backfilled to elevate the filtration system to an appropriate height. Therefore, construction such as this would be labor and time intensive. Furthermore, due to dirt settling and erosion, the filtration system could be damaged due to flash floods during the rainy season. The backfill had the possibility of being washed away. A benefit of this site was proximity of the filter tank to both depths of the pool. Thus, routing the "incentive" piping to the desired location would require minimal materials. The site was perceived to be a place where children would not go, so the chances of damage would be lower. This location would also deter children from walking in an area where water and mud collect, preventing mud puddles.

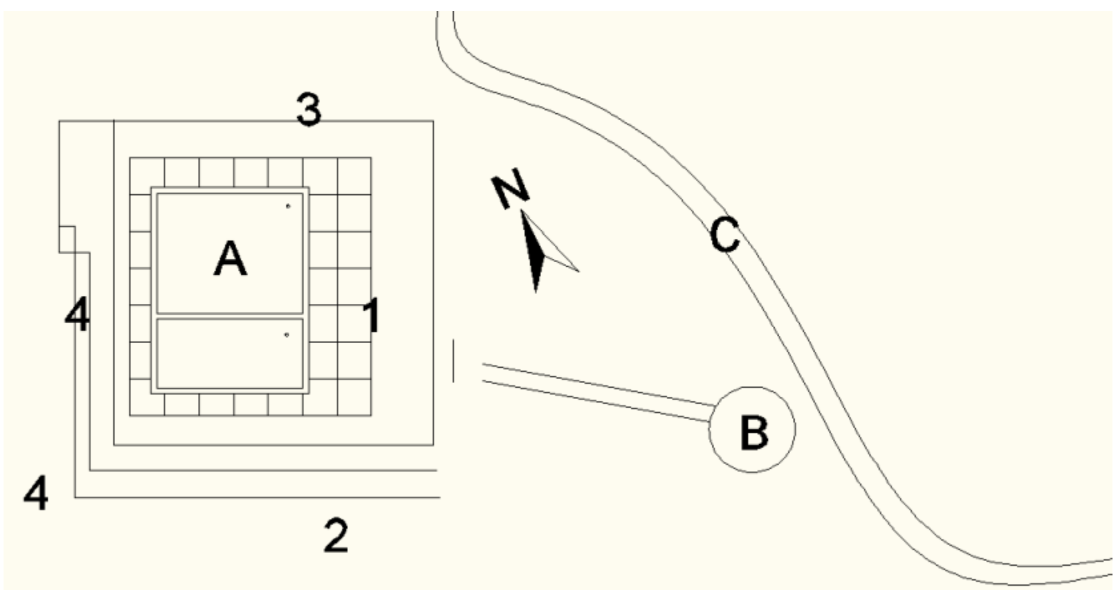

Figure 17. Diagram for filtration system placement (A: pool; B: latrine, C: natural drainage ditch)

The second location (Figure 17, number 2) was near the large polytank used for collecting rainwater. This placement was advantageous because it was at the top of the terracing. However the amount of human activity in the area was high. This heightened the possibility of the filtration system getting broken. Furthermore, the site had limited room for expansion. Lastly, the work needed to prepare the site for construction was high due to the amount of vegetation in the area. The site would require a concrete foundation, and a path up the terracing.

The third location (Figure 17, number 3) considered was by the fence toward the street side of the pool. This site had ample space to work on and was close to the drainage ditch. Another positive aspect was that it did not interfere with general pool activity. Problems with this site were that it was located at the lowest point of the recreation area, and the ground became damp from runoff after rainstorms. A stable foundation would need to be built before the system could be placed there. This placement also resulted in a larger amount of piping needed to reach the incentive area.

Kosinski presented a fourth option (Figure 17, number 4). At this location, the filling tank and the filter tank would be separated, with the filling tank at the highest point at the recreation center and the filter tank on the entrance side of the pool. This position required minimal landscaping, pouring of concrete and digging of dirt for laying the pipe. The placement did not require an excess of exposed piping and was in an area with moderate pool activity.

Overall, location four was chosen. This was one of the more positively ranked sites and was also seen by Kosinski as the best option.

4.2 Filter Construction

The filter system consisted of two parts. The first was a settling/holding tank where the children would take water from the pool and pour it into the tank. This tank was 115 gallons with a height of 113 centimeters and a diameter of 91 centimeters. A 1 inch PVC pipe connected from this polytank to a second polytank at a lower elevation (see Figure 15). The second polytank was an upflow roughing filter with a volume of 222 gallons, a height of 50 inches, and diameter of 40 inches. The larger aggregate was placed on the bottom of the tank up to a depth of 6.25 inches and smaller aggregate on top to a depth of 18.75 inches, for a total filter depth of 25 inches. A gate valve was used to regulate flow from the holding tank to the filter tank. The water exited the top of the roughing filter through a 1 inch PVC pipe and went across the skirt of the pool up onto the ledge of the pool where it discharged water through the incentive back into the pool (see Figure 16).

4.2.1 Overall Cost of Filtration System

The overall cost for the building of the filtration system was 338 Ghana New Cedis (242 USD). This number was determined from the cost of each item used (shown in

Table 3). The materials were purchased in Koforidua, and the blocks and cement were purchased from Anyinam.

Table 3. Cost analysis for filtration system

Item	Quantity	Units	Unit Cost GHS	Total Cost GHS	Unit Cost USD	Total Cost USD
PVC 1" 20ft	3	length	7.00	21.00	$5.00	$15.00
PVC 1" 90° Bend	13	item	1.00	13.00	$0.71	$9.29
PVC 1" T	1	item	1.00	1.00	$0.71	$0.71
PVC 1" Union	2	item	6.50	13.00	$4.64	$9.29
PVC 1" Cap	1	item	1.50	1.50	$1.07	$1.07
PVC 1" Valve Socket	3	item	1.00	3.00	$0.71	$2.14
Brass 1" Gate Valve	1	item	15.00	15.00	$10.71	$10.71
SS100 PVC Glue	1	item	5.00	5.00	$3.57	$3.57
Thread Tape	1	rolls	0.50	0.50	$0.36	$0.36
Polytank Rambo 070	1	tanks	155.00	155.00	$110.71	$110.71
Polytank Syntec 100*	1	tanks	n/a	n/a	$0.00	$0.00
Cement	4	bags	12.50	50.00	$8.93	$35.71
Concrete Blocks	40	blocks	1.50	60.00	$1.07	$42.86
Total				338.00		$241.43

*Left over from 2008-09 construction

4.2.2 FUNCTIONING FILTER SYSTEM

After the filtration system construction was complete, water was added to the holding tank from the pool. The water was allowed to flow through the filter for approximately two hours. After this time, a visual inspection was made of the water entering the filter and exiting the filter, as shown in Figure 18. The clarity of the water appeared to be significantly reduced. However, the MQP team was not able to obtain a quantitative measure of the water clarity, such as turbidity. Additional photographs of the children interacting with the filtration system, incentive, and pool can been seen in Appendix B.

Figure 18. Water before entering the filtration system (left) and after exiting the filtration system through the incentive (right)

4.3 SCHISTOSOMIASIS PREVALENCE

Kosinski (Kosinski 2010) measured the schistosomiasis burden in Adasawase from 2007-2010 and studied how to counter it by implementing various control methods, such as mass treatment and construction of an alternative recreating center. The MQP team assisted with sampling and testing in 2010. Infection rates are shown in Table 4. Approximately 500 individuals participated in the study each year. Each individual in the study provided from 1 to 4 urine samples for testing, resulting in 436 to 1780 samples in any given year. A decline in the prevalence of the disease is evident from 2008 through 2010. There was a decrease of about 21.4% in the number of children infected from 2008 to 2009, and a 13.9% decrease from 2009 to 2010. A decline in the prevalence of the disease is evident since the implementation of the alternative recreating center. Please refer to Appendix E for more information on 2010 Parastiology Results.

Table 4. Infection Data in Adasawase from 2007-2010 (Kosinski, unpublished)

Date	Age (Years)	Number of Samples Screened	Number of Individuals Screened	Percent Positive (Eggs and/or Blood)	Number of Tests per Person (Pre-Treatment)
2007	8-20	436	436	35.1%	1
2008	8-20	1671	474	49.8%	1-3
2009	8-20	1523	437	28.4%	1-4
2010	5-22	1780	585	14.5%	1-4

4.4 Knowledge, Attitudes, and Practices Student Survey

The KAP student surveys were conducted to gain an understanding of the following topics in Adasawase: water usage, sanitation and hygiene, knowledge of schistosomiasis, attitudes and health practices, and use of the swimming pool. Results collected from the KAP surveys directed the project to focus on an educational initiative to implement with the teachers in the schools to raise awareness about the disease, address misconceptions, and increase preventative measures.

The data presented in Table 5 show the demographics of the 85 students surveyed from the three schools in the Adasawase community ranging from Class 1 through Junior High School Form 2. Age instead of class of each student was used to categorize them, since age was not necessarily indicative of a certain class and was highly variable within the classes. A total of 23, 35, and 27 students were surveyed from the Methodist, Presbyterian, and Junior High School, respectively. Thus, the total number of students was surveyed 85.

Table 5. KAP survey student demographics

School	Age (Years)	Female (n)	Male (n)	Total
Methodist	10	0	2	2
	11	4	3	7
	12	1	3	4
	13	4	2	6
	14	4	2	6
	15	-	1	1
	16	-	1	1
Total		**13**	**14**	**27**
Presbyterian	6	2	0	2
	7	0	0	0
	8	1	2	3
	9	2	1	3
	10	2	2	4
	11	1	9	10
	12	3	1	4
	13	1	2	3
	14	1	1	2
	15	0	1	1
	16	0	1	1
	17	0	0	0
	18	0	2	2
Total		**13**	**22**	**35**
Junior High School	10	2	0	2
	11	2	3	5
	12	2	1	3
	13	2	3	5
	14	2	4	6
	15	1	0	1
	16	1	0	1
Total		**12**	**11**	**23**

4.4.1 Association Between New Students and Infection Rates

Table 6 shows associations between infection status and whether a student is new to town or not. Out of the 85 students surveyed, 19 of them had recently moved to Adasawase within the past year (September 2009-May 2010). Twelve of these 19 students (63%) that were new to the town were found to be infected based on testing conducted in June and July 2010. Only 7 of the new students were not infected. There were also 10 students (18%) surveyed that were found to be infected and were not new to town and had been residing in the community for more than a year.

Table 6. Cross analysis of students new to town and infection status

		Tested Egg and/or Blood Positive		Total
		No	Yes	
New to Town	No	46	10	56
	Yes	7	12	19
Total		53	32	85

4.4.2 River and Pool Use

While surveying the children, they were asked to self-report how much time they spent at both the river and the pool each day on a weekly basis. Table 7 shows the total numbers of hours and minutes all the children reported for each day of the week. The intended use of this data was to analyze when the children used the pool most frequently and swam at Tini River, to develop an operations and maintenance schedule for the pool. When the data were totaled, the children reported spending approximately 60 hours per week at Tini River while they reported spending approximately 69 hours per week at the pool. With improved maintenance of the pool, perhaps the time the children spend at the river will decrease and they will therefore be at a lower risk for contracting Bilharzia.

Table 7. Comparison of total hours and minutes children spent at the river or pool on each day according to self-reported data

Days	Time spent at Tini River	Time spent at pool
Monday	8 hrs 30 min	13 hrs 0 min
Tuesday	12 hrs 30 min	12 hrs 0 min
Wednesday	13 hrs 45 min	9 hrs 30 min
Thursday	5 hrs 5 min	12 hrs 0 min
Friday	4 hrs 31 min	14 hrs 15 min
Saturday	11 hrs 51 min	3 hrs 10 min
Sunday	3 hrs 21 min	5 hrs 0 min

These data are graphically represented in Figure 19, where the black bars represent the total self-reported time the children spent at Tini River each day and the gray bars represents the total self-reported time the children spent at the pool each day. The data show that Monday, Tuesday, Thursday and Friday are the most popular days for the pool and that Tuesday, Wednesday and Saturday were the most popular days for the children to visit the river. Based on the data, perhaps operations and maintenance of the pool could take place on the days that children are less likely to visit the pool such as Saturday, Sunday, and possibly Wednesday.

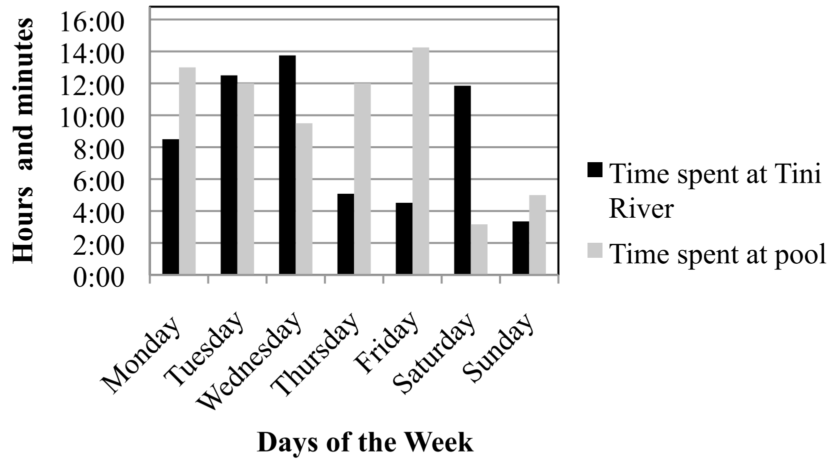

Figure 19. Comparison of children's total self-reported time spent at the river and pool for each day of the week.

4.4.3 Characterized Health Issues and Diseases

Questions 10 and 18 on the KAP survey were opened ended and allowed the students to describe perceived health risks that they identified in their community (Question 10) and what they have learned in school about health and disease (Question 18). The answers were categorized as shown in Figure 20. Students were allowed to provide more than one answer to each question.

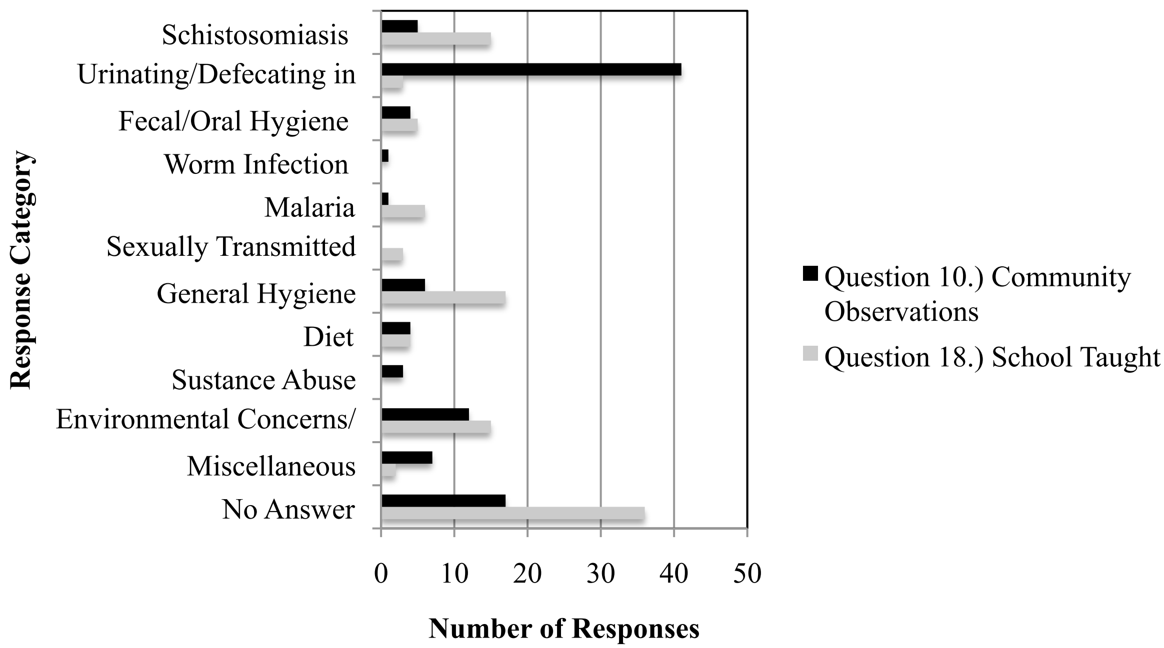

Figure 20. Perceived health risks and education on health issues

Urinating/defecating in public places was classified as the most frequently reported health issue in the community from the student's perspective with 41 responses in this category. With regard to health issues taught in school, general hygiene had the most responses (17). Schistosomiasis was noted as a health risk by 5 students and 15 students indicated that schistosomiasis was taught to them in school. Seventeen students did not provide an answer for question 10 and 36 did not answer question 18. Ten of the students did not answer either question.

4.4.4 Knowledge of Schistosomiasis

While administering the survey, it became apparent that some children may have been confused regarding how Bilharzia is contracted and symptoms of Bilharzia. Some children would answer "swimming in the river" for a symptom, and then answer "bloody urine" to how

Bilharzia is contracted. However, after analyzing the data it became apparent that although there were a few outliers that made this mistake when answering, the majority of the children answered the question correctly and had good knowledge of how the disease is contracted and the main symptom of the disease. Other answers received such as, chewing a leaf from a certain tree, swallowing water while swimming, or I don’t know, are not specifically listed in Figure 21 because these answers are irrelevant to whether or not the children were confusing symptoms with how the disease is contracted. All answers were grouped into three categories during analysis, “Correct”, “Incorrect”, or “Did not know”.

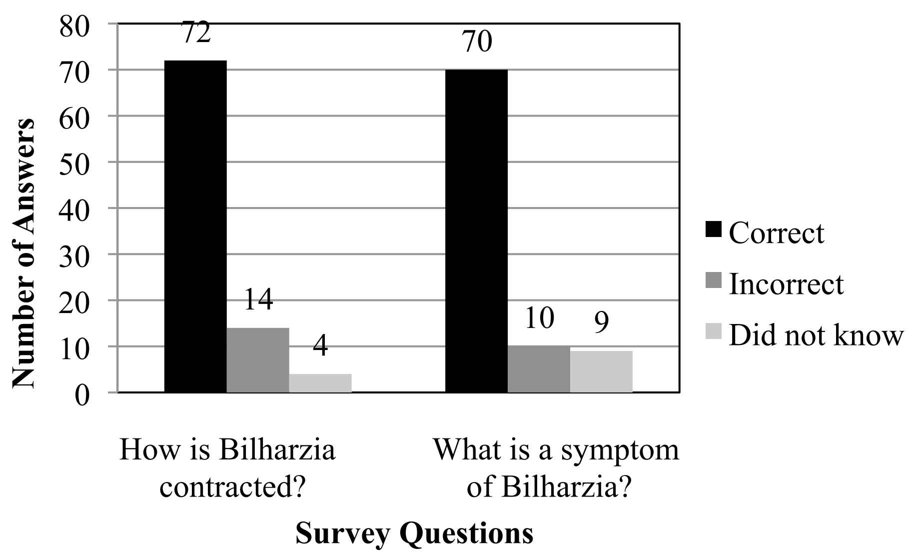

Figure 21. Graph displaying the comparison of knowledge and the ability to differentiate between how Bilharzia is contracted and its main symptom.

According to the data, approximately 80% of the children surveyed knew that Bilharzia was contracted from swimming in the river, and approximately 79% of the children knew that bloody urine was the main symptom of a Bilharzia infection. Figure 21 shows that the majority of children did have knowledge of how Bilharzia is contracted and its main symptom. The black bars are the number of correct answers received for each question, and the dark gray bars are the number of incorrect answers received for each question. The light gray bars indicate the number of children who did not know the answer to the survey question. The total number of answers received for “How is Bilharzia contracted?” was 90 and a total of 89 answers were received for “What is a symptom of Bilharzia?” The children were able to choose multiple answers for each question.

While surveying the children about how Bilharzia was contracted, approximately 7% answered that it could be contracted from chewing a leaf from a certain tree (This answer was categorized as an incorrect answer when the data were analyzed.) During the surveys students reported that one of the headmasters of the schools was telling the children it was possible to get Bilharzia from a certain tree; this observation mainly pertained to the Presbyterian Elementary School. The misconception that this was possible was discussed during the informational session held with the teachers and headmasters of Adasawase and it was explained that although chewing on this particular leaf may turn the urine red, it does not result in Bilharzia.

4.4.5 Student Recognition of Disease Name

Questions 11 and 12 on the KAP survey inquired about disease name recognition and the results are shown in Figure 22. The students were asked if they knew what schistosomiasis was by presenting the disease name in a colloquial Twi phrase as “bloody urine,” or by a synonymous medical term, Bilharzia. 93% of the students recognized schistosomiasis when described as “bloody urine,” whereas only 24% recognized it as Bilharzia. Sixty-five students did not associate schistosomiasis with the medical name, Bilharzia.

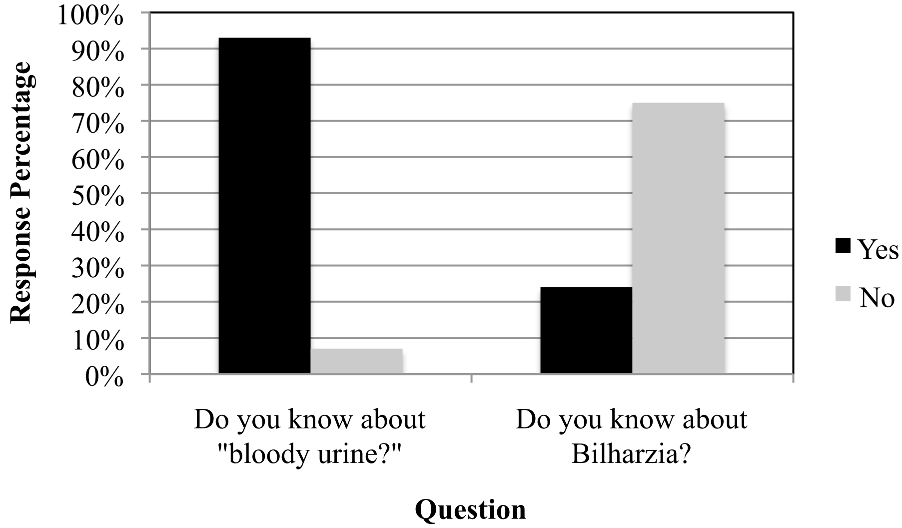

Figure 22. Student recognition of disease name

4.4.6 Self Reporting

Self-reporting is a method of determining infection prevalence, but is not a completely accurate portrayal of the study population. Some variables that can influence responses are language barriers, interpretative differences, and a lack of education on the disease epidemiology/pathology.

Figure 23 shows the number of responses for students reporting whether they had ever seen red or blood in their urine. It was hypothesized that students should be consistent with answering "yes" or "no" for each question, instead of seeing different answers for each one. However, the distribution of answers varies between the two questions. Table 8 shows the numerical distribution of the answers for infected and non-infected students. The responses for red urine and bloody urine were not consistent. For instance, 36 students responded yes to seeing red in their urine, but 51 said yes to seeing blood. Forty-nine students said no to seeing red in their urine and 34 said no for blood being present in their urine. More students responded that they have seen blood in their urine than red.

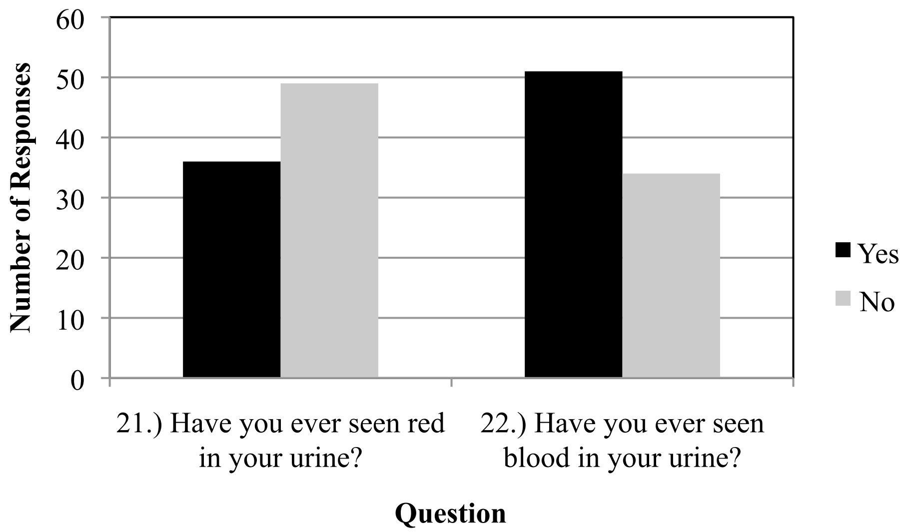

Figure 23. Self reporting for red or blood in urine

Table 8. Numerical distribution for self reporting responses

		Infected		Total
		No	Yes	
Red in Urine	Yes	20	16	36
	No	43	6	49
Blood in Urine	Yes	33	18	51
	No	30	4	34
Total		126	44	170

Among students that were infected, 16 of 22 responded yes to seeing red in their urine, and 18 to seeing blood in their urine. There was more variability in responses among uninfected students.

4.4.7 SELF-REPORTED VS. OBSERVED COMMUNITY URINATION LOCATIONS

Figure 24 shows a comparison between self-reported urination locations and what the students observe from members in the community, which are questions 6 and 7 on the KAP survey. Since transmission of the disease continues when an infected individual urinates in the water body releasing larval forms of the parasite, insight was gained by understanding if this was still a prevailing practice. The distribution of responses is variable among location for both the self-reported and community observed categories.

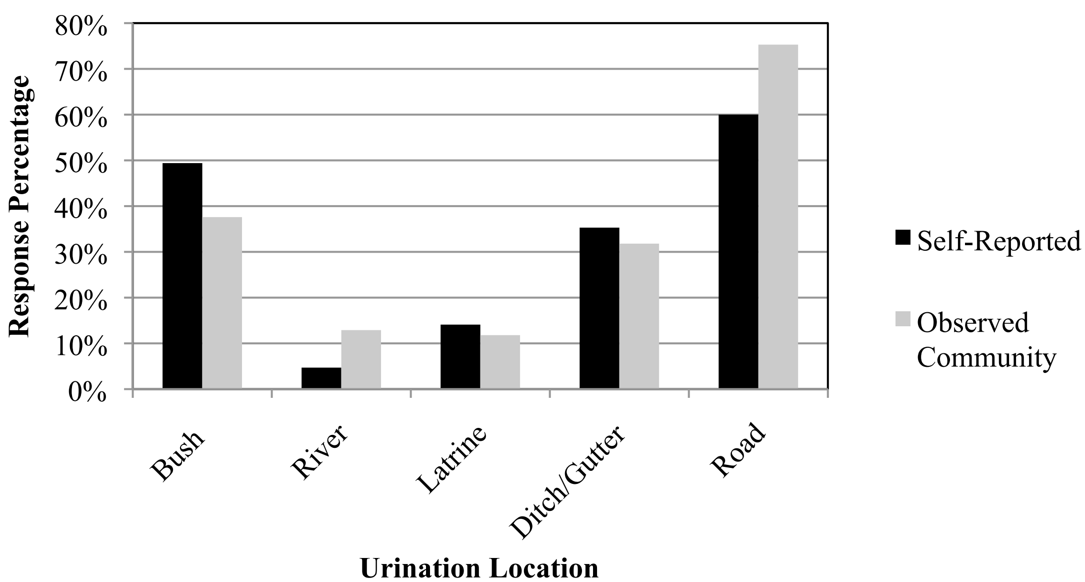

Figure 24. Self-reported vs. observed community urination locations

The most commonly self-reported locations for urination are the road and bush. These were also the most commonly observed urination locations. The river has the least amount of responses as a self-reported location and latrines are observed to be the least used in the community.

Figure 25 shows the responses for students that tested positive for hematuria/eggs and where they self-reported as urination locations in comparison to what they observe from members in the community.

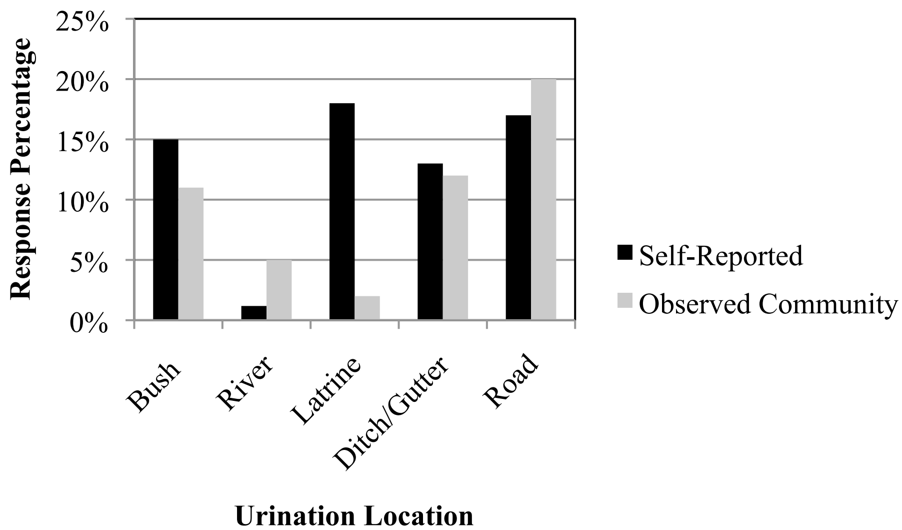

Figure 25. Self-reported vs. community observed urination locations for infected students

Students that tested positive in previous years were chosen at random and asked to perform the KAP survey. By studying this specific population, data was collected on understanding the behavior of an infected individual. The river has least responses for a self-reported location and the latrine has the least amount of responses for community observed.

4.5 Teacher Knowledge Attitude and Practices Focus Groups

In order to gather information on the knowledge of Bilharzia among the teachers of Adasawase, focus groups at each school were conducted using ten questions (see Appendix D) adapted from the Knowledge Attitudes and Practices survey formulated by Kosinski (Appendix C). The focus groups were conducted in a discussion-style interview with the teachers of

Adasawase who were voluntary participants. A local Ghanaian interpreter was used to translate questions from English to Twi and then to translate the answers in Twi back to English, while an MQP team member recorded the answers by hand. The PowerPoint survey that was used to conduct the surveys with the school children was not used for the focus groups with the teachers. The MQP team was interested in seeing if the Bilharzia knowledge level was the same throughout all people of the community regardless of age, or if the adults were better informed about the disease. Data were also collected on what health topics are taught in the schools and whether or not children self report Bilharzia symptoms to their teachers.

The first focus group was held at the Junior High School in Adasawase where there were six teachers in attendance. The teachers reported that they had all attended a one day Bilharzia workshop in Kwabeng (the capital of the Atiwa district). They also informed the MQP team that Ghana Health Services was attempting to mass treat all the children within the Atiwa district with Praziquantel. At the workshop, the teachers were instructed how to administer Praziquantel to the children; however, the schools had not yet received the Praziquantel at that point. The teachers thought the mass treatment program was an effective way of lowering the prevalence of Bilharzia in their town but expressed concern about the children in the town who did not attend school.

The Junior High School teachers explained that their curriculum includes Integrated Science which is the class in which all health topics are taught. All teachers are required to include health topics within his or her lesson plan. They teach about sexually transmitted diseases, especially AIDS/HIV, and other communicable diseases. This information is included on exams and students are typically asked questions that involve knowledge of disease symptoms, causes, and how these particular diseases are contracted.

Although only a few of the teachers present offered answers to the Bilharzia questions, it was established that the teachers all should have some knowledge of the disease because it is taught in the university. The teachers knew that Bilharzia is contracted through contact with water and that a small snail is the causative agent. They were also aware that the main symptom associated with a Bilharzia infection is when an individual urinates blood. The teachers were also familiar enough with the life cycle to understand that. They had a good comprehension of the damage that the disease can cause to a person's urinary tract and one teacher said that his son was once infected with Bilharzia and complained of pain in his penis. The teacher suggested that designing an educational study and implementing a pilot study would be beneficial for the town.

At the Methodist Primary School seven teachers attended the focus group held by the MQP team with a distribution of three females to four males. The headmaster of the school system was included in the group as well. When asked about health topics taught within the curriculum, the teachers explained that every teacher must teach about AIDS, both in the lower and upper primary classes. The school has a syllabus, textbooks, and wall charts that are utilized when teaching about health topics. The textbook used to teach about health topics is called "Building Healthy Bodies and Individuals". The children are expected to retain this knowledge and are tested on the health material during their exams.

The teachers were aware that Bilharzia is contracted by contact with a contaminated body of water. However, they were under the impression that just being in the water with an individual who had the disease could put a person at risk of getting the disease. They did not understand that an infected individual has to urinate in the water in order for them to put others at risk of contracting the disease. When asked about the symptoms associated with a Bilharzia infection, the teachers listed off painful urination, the presence of blood in the urine, and itching of the penis and vagina. The teachers said that the children have been self reporting more often since Bilharzia control work began in Adasawase began in 2007. When the children report Bilharzia symptoms to their teachers, the teachers instruct their students to go to Ghana Health Services to seek treatment. The teachers learn about Bilharzia from textbooks, workshops, and handouts.

The next school visited for a KAP focus group was the one of the Kindergartens (KG) in the town. There were four female KG teachers in attendance. The teachers explained that due to the younger age of their students, the health topics that were taught were centered primarily on overall healthy lifestyle habits. They teach that the children should weed around buildings in order to keep mosquitoes away and reduce the prevalence of malaria. They also teach the children that they should eat healthy foods and wash their hands before eating and after they go to the bathroom. The two diseases they mentioned including in their curriculum were malaria and cholera.

When asked if the children self report having Bilharzia symptoms, the teachers replied that the children do, but that the occurrence has decreased since Bilharzia control work started in the town three years ago. The teachers recognized Bilharzia by its colloquial name ("juso moja") and were aware that it is contracted through contact with contaminated water sources. They seemed more informed about the intestinal strain of schistosomiasis however, and told the MQP group that they knew it was passed through defecation into water bodies. The teachers believed that the causative agent was a small animal called "schisto" and also were under the impression that Bilharzia could be contracted by eating a particular nut which would turn an individual's urine bloody.

At the Presbyterian Primary School, the teachers explained that general health topics were taught in their curriculum and that no specific health issues were stressed. Natural science and integrated science are the classes that health topics are taught in and the students are instructed on how to keep themselves healthy overall.

The teachers at the Presbyterian school were well versed in the life cycle of *Schistosomiasis haematobium*, and realized that a water body becomes contaminated once an infected individual urinates in the water. In their lessons, the teachers tell the children not to swim in Tini River to avoid becoming infected with the Bilharzia. The teachers mentioned bloody urine and painful urination as common symptoms associated with a Bilharzia infection. The children self report much less since the Bilharzia control program in Adasawase was begun. The teachers claimed that they learn about Bilharzia from television, newspapers, and by attending the Bilharzia workshop in Kwabeng. One teacher admitted to having Bilharzia at one point and that he was treated at the hospital for the disease.

CHAPTER 5: DISCUSSIONS AND IMPLICATIONS

The project team spent two months in Ghana conducting project work to address control of schistosomiasis in the rural village of Adasawase. Several challenges were encountered in Ghana, including lack of interest of the towns people in helping with project work and lack of Bilharzia knowledge in the school children, the teachers and adults of Adasawase. The impact of different control methods on the disease prevalence were assessed to prioritize the work and make recommendations for the future. The following sections discuss the findings of this project.

5.1 FILTRATION SYSTEM

Construction of the filtration system was complicated due to corruption, time constraints, and lack of community ability for involvement. There are issues of corruption in Anyinam and in many parts of Ghana, which made it difficult complete work on the water recreational facility. Price fixing was one of these problems. When building the pool in 2008-09, Kosinski's team asked for concrete prices from shops in the town of Anyinam and found the shops had raised their prices for the American team. Knowing the usual price from a Ghanaian team member, Kosinski discovered that the shops were participating in price fixing. This meant that upon going into the first shop, word had already spread to the rest of the shops that foreigners were looking to buy concrete (Kosinski, personal communication). This fostered a lack of trust between the American team and the shop keepers in Anyinam. In addition to the lack of trust, a lack of items made lengthy trips to Nkawkaw (30 min.), Koforidua (1.5 hours), and Accra (3 hours) necessary. Furthermore, if the items bought could not fit under the seat or in the trunk of the van, an extra seat or alternative transportation was arranged. Depending on the length of the trip, the price could be costly.

The community of Adasawase has limited financial resources. On average, townspeople make 3-4 Ghanaian New Cedi's per day (Kosinski, personal communication). This is the equivalent of 2.14 - 2.85 US dollars per day. From the time Kosinski left Ghana in 2009 until returning in 2010, the community could not afford to maintain the pool. The cost of lost labor hours was too great for them to justify spending time on pool maintenance. The community does have a program where people serve time for the community by volunteering for projects. The program should be evaluated to see if it could be used to subsidize the cost of operations and maintenance.

The placement of the filling tank was at the highest point on the site, with the upflow roughing filter adjacent to the pool and the incentive running along the middle of the pool. The children were observed walking up the provided concrete path, using the stairs, and dumping water in to the tank. They used buckets provided as well as milk cans, lunch pails, and other receptacles to transport the water. The children would either use the path provided to get back into the pool, or hop down the terracing and directly back into the pool. In the latter case, the children track dirt into the pool from their feet. To avoid the extra dirt in the water, a second path made of concrete or blocks could be constructed along the route the children used through the terracing.

5.1.1 Overall Filtration System Effectiveness

As discussed in the results chapter, the filter produced effluent water with a visibly lower clarity compared to the influent water entering the filtration system (Figure 18). The team was unable to collect adequate data on the effectiveness of the filtration system because there was a lack of equipment and time. Had the resources been available, a number of analyses would have been made.

First, the filter effectiveness would be determined by measuring filter influent and effluent turbidity over time. Quantitative measures of effluent quality would demonstrate the reduction in particulate matter and could be used to determine the filter run time prior to backwashing. Information on the required backwash frequency would provide information on maintenance requirements for the filter. Second, turbidity would be monitoring in the pool itself over time, and correlated to use of the pool by the children. While the filter may be able to provide clarified water for filling the pool, particulate matter can enter the pool through other means. For example, children can track in dirt on their feet when they enter the pool. Measurements of the pool water would provide information on whether the filtration system was an adequate control mechanism, or whether other modifications to the pool usage are necessary to maintain the water clarity.

5.2 Infection Rates Analysis

Kosinski's prior research in Adasawase provided the frame work for her doctorate thesis. Her hypothesis was that the water recreation area would change the environment in such a way that use of river water would decrease and in turn reduce schistosomiasis prevalence.

Her initial work in December of 2007 and June of 2008 was to assess the burden the disease had on the children of the community to see if an intervention was necessary. In June of 2008, she found that 49.8% of the students tested were positive for blood or eggs. Based on this data, she started the plans for implementing an alternative water recreation area.

The design for the water recreation area was a collaborative effort among schoolchildren, college undergraduate and graduate students, engineering and health professionals, and the local community members. Individuals involved in the design and construction were nationals of Ghana and the United States. The goal of the structure was to meet community needs, be economically appropriate, and be attractive to users. Construction was completed by team and community members in June, July, and August of 2008 and finalized in the summer of 2009 (Kosinski 2010).

In June of 2009, children were tested four times to accurately establish natural, annual reinfection rates. Students in the study were treated by nurses from Ghana Health Services with Praziquantel according to WHO standards after infection testing. Children were also asked about their use of river water and the new established water recreation area (Kosinski 2010).

In June of 2010, schistosomiasis reinfection rates were determined for schoolchildren 1 year post-intervention. The infection rate decreased from 49.8% in 2008 to 28.4% in 2009. In 2010 there was prevalence rate of 14.5%, so cumulatively from 2008 to 2010 there was 35.3% decrease. A decline in the prevalence of schistosomiasis can be attributed to multiple factors including mass treatment with Praziquantel, the installation of the water facility, and lastly, the presence of Kosinski's research team in the community from 2008-2010. However, it is not possible to determine the individual impact of each of these factors. With regards to Kosinski's team, Kosinski has raised awareness for the disease and preventative measures through the community by addressing the target population at different levels: community leadership council with the head chief and elders, schools administrators, and health workers. While working in the schools, her team educated the students and teachers about the disease, the life cycle, symptoms, and long term risks if infections persist. The sustainability of what has been accomplished is not known. Without an external presence to oversee mass treatment, maintain the pool, and plan educational initiatives, infection rates could rebound. Community interest was heavily dependent on the presence of a research team. The long-term impact of the work completed on schistosomiasis infection rates can only be assessed if a research team returns to Adasawase in the future.

5.3 Knowledge Attitudes and Practices Survey

The Knowledge Attitudes and Practices survey allowed the MQP team to gather pertinent information of the general knowledge of Bilharzia among school-aged children. The development of a colorful and interactive survey conducted on a laptop made taking the survey attractive to the school children in Adasawase. Out of the 82 children who were asked whether or not they enjoyed taking the survey, only 7 of them (approximately 9%) stated that they did not like the survey. The children enjoyed the interactive aspect of being able to point out their answers and the ability to press some of the computer keys to advance the PowerPoint slides.

Although the children cooperated with the MQP team and participated in the survey, the improvements made to the KAP survey did not necessarily ensure accurate answers from the children. According to data from Kosinski (personal communication), which included observed time spent at Tini River for 18 of the children surveyed, one child who reported not knowing of Tini River was spotted at the river for a total of 65 minutes between August and November of 2009. Another student, who claimed to not know of Tini River was 17 years old and has lived in Adasawase for at least the past 3 years.

It was assumed that the school children would have no reason to lie about their knowledge of diseases and specifically their knowledge of Bilharzia. However, self-reporting data may be unreliable because children may answer what they believe the interviewer wants to hear or will answer untruthfully so they do not get into trouble. For example, children may be reluctant to admit that they urinate or defecate in or near the river because they are aware of the stigma connected to such behavior.

5.4 Health Education Initiative

The MQP team originally had planned on going from class to class teaching about Bilharzia with the help of a local cultural interpreter. Due to time constraints and factors that had not been planned for such as teacher interest, an informational session on Bilharzia for just the teachers of Adasawase was pursued. A continued theme throughout the project was sustainability. The MQP team applied the idea of sustainability to the health education initiative. By educating the teachers of Adasawase on Bilharzia, they can then share their knowledge with their students in future years.

The MQP team's cultural interpreter approached the headmasters of each school in the Adasawase school system on July 16, 2010 about the MQP team giving an informational session on Bilharzia. The team's cultural interpreter heard back from the schools on July 19, 2010, and the headmasters of each school had spoken with one another and wanted to have the MQP team hold one informational session for the entire town's school system at once. The headmasters organized a meeting on July 23, 2010 which the MQP team was invited to attend. All teachers and headmasters congregated at the Junior High School for the meeting.

The teacher's interest in participating in an educational forum was not consistent with their prior actions. In the past, while doing urine sampling, the teachers seem disinterested in teaching the children. The teachers would often socialize amongst themselves or use their cell phones when they should have been interacting with their students or teaching. It was learned that the teachers are not paid well and do not consistently receive paychecks, contributing many times to a lack of interest in teaching the students. The commitment of the headmasters and teachers to learning more about Bilharzia at an informational session after school hours indicates their interest in the health of their students.

It is the hope of the MQP Team that the teachers of Adasawase will educate students about Bilharzia each year. This method of spreading knowledge about Bilharzia was chosen so that it was not only one select group of students that received the information. The sustainability and effectiveness of education could be assessed if a research team can return to Adasawase to survey the school children again in a future year.

According to literature on schistosomiasis control, the use of only one control method alone will not help lower prevalence. Multiple methods of control must be implemented simultaneously to obtain results (Acha and Szyfres 2001). This is the reason for implementing a health education initiative in Adasawase, in addition to mass treatment and creating the alternative recreation facility. Through the survey, misconceptions about the disease were determined. The health education initiative that was put in place in Adasawase served to educate the teachers of the town about Bilharzia so they could spread that knowledge to their current and future students. The focus groups allowed teachers to ask questions about Bilharzia as well. For example, the team noted the pool was not an appropriate habitat for the *Bulinus* snail, and thus the children would not contract Bilharzia from swimming in the pool. Many of the people in the town also assumed that swimming in the water at the Tini waterfalls put them at risk of contracting Bilharzia. The MQP team explained that due to the lack of vegetation, the *Bulinus* snail would not thrive in the pool, and similarly, that the cold temperature and fast pace of the water of Tini waterfalls would not be hospitable to the snails. It was explained that without the *Bulinus* snail as an intermediate host, the miracidium would not be able thrive and mature into cercariae, even if infected individuals were urinating in those particular water bodies and depositing schistosome eggs.

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Chapter 7: Appendices

Appendix A: Price Lists

Table 9. PVC and piping store

Size	Item	Description	Price (GHS)	Price (USD)
¾”	PVC Pipe	20ft	GHS 5.00	$3.50
1.0”	PVC Pipe	20ft	GHS 7.00	$4.90
1.25”	PVC Pipe	20ft	GHS 9.00	$6.29
1.5”	PVC Pipe	20ft	GHS 11.00	$7.69
4”	PVC Pipe	10ft	GHS 8.00	$5.59
1.5”	PVC Connection	T	GHS 1.50	$1.05
1.5”	PVC Connection	45˚ Elbow	GHS 1.20	$0.84
1.5”	PVC Connection	L	GHS 1.00	$0.70
2”	PVC Connection	45˚ Elbow	GHS 2.00	$1.40
4”	PVC Connection	T	GHS 3.50	$2.45
4”	PVC Connection	45˚ Elbow	GHS 3.00	$2.10
4”	PVC Connection	L	GHS 3.00	$2.10
1.5-1.25”	PVC Reducer	Connects two different size pipes	GHS 2.00	$1.40
2-1”	PVC Reducer	Connects two different size pipes	GHS 3.00	$2.10
1.5-1”	PVC Reducer	Connects two different size pipes	GHS 2.00	$1.40
1”	Brass Ball Valve	Ball w/ thread inside	GHS 10.00	$6.99
1”	PVC Valve Socket	Fits into a 1” valve w/ thread so you can connect a non threaded PVC to it	GHS 1.00	$0.70
¾”	Plastic Foot Valve	Prevents backflow	GHS 10.00	$6.99
1”	Plastic Foot Valve	Prevents backflow	GHS 12.00	$8.39
1”	Brass Foot Valve	Prevents backflow	GHS 15.00	$10.49
	Brass Gate Valve		GHS 15.00	$10.49
¾”	Stopcock (K54)	45 degrees	GHS 10.00	$6.99
	Thread/seal tape		GHS 0.50	$0.35
	PVC Glue	SS100	GHS 5.00	$3.50

Table 10. Polytank store

Diameter/ Length (in cm)	**Height (in cm)**	**Model Name**	**Capacity (in liters)**	**Capacity (in gallons)**	**Price (GHS)**	**Price (USD)**
91	113	Rambo – 070	700	155	155.00	$108.39
102	120	Rambo – 100	1000	222	225.00	$157.34
120	126	Rambo – 140	1400	311	300.00	$209.79
120	151	Rambo – 180	1800	400	405.00	$283.22
150	136	Rambo – 250	2500	555	505.00	$353.15
150	176	Rambo – 300	3000	666	640.00	$447.55
150	200	Rambo – 350	3500	777	720.00	$503.50
146	227	Rambo – 400	4000	888	825.00	$576.92
180	185	Rambo – 450	4500	1000	900.00	$629.37
185	200	Rambo – 500	5000	1111	945.00	$660.84
189	220	Rambo – 600	6000	1333	1,065.00	$744.76
201	233	Rambo – 700	7000	1555	1,240.00	$867.13
212	235	Rambo – 850	8500	1888	1,400.00	$979.02
167	101	Hippo – 100	1000	222	300.00	$209.79
176	127	Hippo – 200	2000	444	495.00	$346.15
196	153	Hippo - 280	2800	622	700.00	$489.51

APPENDIX B: CHILDREN INTERACTING WITH POOL AND FILTRATION SYSTEM

The following are a selection of photographs showing the children interacting with the pool and the filtration system on opening day July 17, 2010.

Figure 26. Children collecting water in various receptacles

Figure 27. A Methodist Primary School female lifts a bucket to place on her head

Figure 28. Children waiting in line to pour water into the holding/settling tank

Figure 29. Children playing with the water being discharged from the incentive

APPENDIX C: KNOWLEDGE ATTITUDES AND PRACTICES SURVEY

Subject ID: ______________________ Date: ____________________

Age: ______________ Sex: M / F ____________________________

Occupation: ____

KAP: Water

1. Do you have a house connection for water? Y / N
2. Do you drink water from a house connection? Y / N
3. Do you drink sachet water? Y / N
4. Do you drink river water? Y / N   Which river(s)?
5. Do you drink rain water? Y / N
6. Do you drink water from a public standpipe?
7. Do you drink water from a house connection? Y / N
8. Do you drink water from another source? Y / N   What source(s)?
9. Do you use river water for washing, cooking, and bathing? Y / N   Which river(s)?
10. Do you use rain water for washing, cooking, and bathing? Y / N
11. Do you use public standpipe water for washing, cooking, and bathing? Y / N
12. Do you use house connection water for washing, cooking, and bathing? Y / N
13. Do you use water from another source for washing, cooking, and bathing? Y / N
    What source(s)?
14. Do you fetch water? Y / N
15. Do women in your house fetch water? Y / N
16. Do small children in your house fetch water? Y / N
17. Does anyone else in your house fetch water? Y / N

KAP: Sanitation and Hygiene

1. Do you have a ***latrine inside*** your house compound? Y / N
2. Do you have a ***water closet inside*** your house compound? Y / N
3. Do you ***usually*** share a ***latrine*** with another family? Y / N

4. Do you ***usually*** use a ***public*** latrine? Y / N
5. Do people in your town defecate in public places? For example, in the bush, along the road, in ditches, etc.?
    a. If Yes, do you know why?
6. When at home, do you ***usually*** defecate in ***either*** a water closet or a latrine?
7. When at home, do you ***usually*** defecate on the ground or in the bush?
8. When at work or school, where do you go to defecate?
9. When at farm, where do you go to defecate?
10. Are public latrines in your town generally clean or dirty?

KAP: Knowledge of Disease

1. How would you know if a person had Malaria? What are symptoms of the disease?
2. How would you know if a person had Bilharzia? What are symptoms of the disease?
3. How would you know if a person had Worms? What are symptoms of the disease?
4. How would you know if a person had Diarrhea? What are symptoms of the disease?
5. What are the causes of Malaria?
6. What are the causes of Bilharzia?
7. What are the causes of Worms?
8. What are the causes of Diarrhea?
9. What is the best way to prevent Malaria?
10. What is the best way to prevent Bilharzia?
11. What is the best way to prevent Worms?
12. What is the best way to prevent Diarrhea?
13. Have you suffered from a fever and chills?
14. Have you ever seen blood in your urine?
15. Have you ever seen worms in your stool?
16. Have you ever had a problem with frequent defecation / stomach pains / watery stool?

KAP: Attitudes and Practices

1. Do you eat with your hands? Y / N
2. Do you wash your hands before eating? Y / N / Sometimes

3. Do you use **soap** when you wash before eating? Y / N / Sometimes

4. Do you wear shoes or sandals? Always / Sometimes / Never

5. If ***Sometimes*** or ***No***, when do you **NOT** wear shoes or sandals?

(a) At home (b) Farm (c) Playing (d) In school (e) Other___________

6. Do you wash your hands after urinating/defecating? Always / Sometimes / Never

7. Do you wash with **soap** after urinating/defecating? Always / Sometimes / Never

8. Where do you go when you are not feeling well / ill?

(a) Local clinic (b) Hospital (c) Traditional Healer (d) Chemical Shop (e) Spiritualist/Religious (f) Stay home (g) Other

9. What does your family do with **household** rubbish?

(a) Rubbish dump (b) Bush (c) Bury it (d) Burn it (e) Other___________

10. What do you do with litter (ex. Small papers, plastic bags) when you are not home?

(a) Drop on ground (b) Rubbish bin (c) Pocket or bag (d) Other ___________

11. Where do you get information about health? From whom? _________________________

12. Do you know what an ***Insecticide Treated Bed Net*** is? Y / N

13. Do you swim, wash, or play in a river or pond in this town ***or any other place***? Y / N

If ***Yes***, where? ___________________________ How often? ___________________________

14. Do you sometimes ***urinate*** in or near a river or pond? Y / N

15. Do you sometimes ***defecate*** in or near a river or pond? Y / N

16. Do you cook or help cook? Y / N

17. Have you ever seen your urine red? Y / N If ***Yes,*** during this past week? Y / N

18. Do you easily get tired? Y / N

19. Have you had a fever or chills in the past three days? Y / N

20. Have you taken any medicine in the past three days? Y / N

The following questions are designed for a discussion-style interview. The interview would take place between a translator and a willing participant. The translator would initiate a discussion on the following topics and then would ask appropriate follow-up questions related to the same subject.

1. Translator offers an explanation of the nature of the work being done by researchers from Tufts University with respect to water, health, and Bilharzia (schistosomiasis). Translator asks if the participant is familiar with the work, and if (s)he has any questions, comments, or thoughts about the work that (s)he would like to share.

2. Translator asks participant to talk about the types of projects that are currently underway in the town (economic, alternative livelihoods, health outreach, literacy/numeracy, etc.).

3. Translator asks participant to talk about some of the general health concerns facing the community, and to comment on how the community is addressing, or hoping to address these issues.

4. Translator asks about water use by members of the participant's household and by members of the community in general. For example, discussion topics might include: common water sources, water quality/quantity, water use in dry and wet seasons, the price of water, and recreational water use.

5. Translator asks about typical roles and responsibilities of children, women, and men in the community with respect to water.

APPENDIX D: KNOWLEDGE ATTITUDES AND PRACTICES SURVEY WITH TEACHERS

1. What topics about health and disease do you teach in class? How do you teach it?
2. What do you think is the best way of teaching about disease/health to your class? What has worked and what has not worked?
3. Do you know about Bilharzia/bloody urine?
4. How do you get Bilharzia/bloody urine?
5. What are the symptoms of Bilharzia/bloody urine?
6. How do you prevent Bilharzia/bloody urine?
7. What do you tell your students about Bilharzia?
8. Has anyone in your family had Bilharzia? If yes, how was it treated?
9. If a student tells you that they have bloody urine or that it hurts to urinate, what do you do or tell them?
10. How do you test for knowledge and understanding of health topics that you do teach?

<u>D/A JHS Teacher Survey Answers:</u>

- 6 people in attendance
- Teachers stated that they attended a workshop last week on Bilharzia in Kwabeng (1 day)
- Ghana Health Services was attempting to mass treat all the children in the district
    - Schools have not yet received PZQ to treat kids
    - Teachers asked how the rest of the kids in the community will get treatment if not in school
- Integrated Science is taught at the JHS
    - They cover many topics
    - STDs (AIDS/HIV)
    - Communicable Diseases
    - Included in Social Studies
    - Every teacher must include health topics in their lessons
    - Diseases are included on exams
    - What is the disease?
    - What are the causes?
    - How does one get the disease?
- Bilharzia (Schistosomiasis)
    - Found mainly in water
    - Causative agent is a small snail
    - Symptoms
        - Infected person urinates blood
    - Urinates in water

- Causative agent injures urinary tract
    - Teachers must learn about this in school
    - One of the teacher's sons had it and complained of pain in his penis
- Ideas
    - Design a educational study and implement a pilot study

Methodist Primary School Teacher Survey Answers:

- 7 people in attendance (3 females and 4 males)
- Head teacher and coordinator attended meeting
- Health
    - Every teacher must teach about AIDS
    - Both in lower and upper primary classes
    - They use charts in class
    - They have a syllabus and textbooks for health topics
    - The children are tested on health topics
- Bilharzia (Schistosomiasis)
    - Water related issue
    - Contract by contact with contaminated water
        - A person can get Bilharzia just from being in the same water at the same time with another person who has Bilharzia
    - Symptoms
        - Painful urination
        - Blood in urine
        - Itching of penis and vagina
    - Don't go to contaminated water (River or stream)
    - Visit Health services for treatment
    - Students have come to teachers to self report since Karen started her work in Adasawase
    - Where do they learn about Bilharzia?
        - Textbooks- found on own time
        - Workshops
        - Handouts
    - Environmental studies
        - Chapter in textbook is called "Building Healthy Bodies/ Individuals"

D/A KG Teacher Survey Answers:

- 4 female teachers
- What health/ disease practices are taught?
    - Malaria
    - Weed around buildings

  - Eat healthy foods
  - Wash hands (after bathroom and before eating)
  - Cholera
- Do Children self report?
  - Yes, children do self report
  - They used to complain more but not as much recently
- Do the teachers know about Bilharzia?
  - Yes. “Bloody urine” (aka “Jusomoja”)
  - Small animal- called schisto
  - Both in infested water and contract disease
  - Enter water bodies and passed through feces- enters water
  - Take “nuts”- turns urine bloody
- Swimming Pool
  - Not a topic they talk about in class
  - If cases come up they tell the children not to go to the river

<u>Presbyterian Primary School Teacher Survey Answers:</u>

- What health topics are taught in the school?
  - No specific topics
  - General Health
  - How to keep yourself healthy
  - Natural Science/ Integrated Science
- Bilharzia
  - They know about it
  - When person urinates in river and then other people go in the river they become infected
  - Bloody urine
  - Painful urination
  - Teachers tell the children not to go to the river in their lessons
  - One teacher had Bilharzia and went to the hospital for it
  - After Karen started her work in Adasawase, the children self report less
  - They learn about Bilharzia from TV, newspapers, and the Kwabeng workshop they attended

APPENDIX E: 2010 PARASITOLOGY RESULTS

Table 11, shows the dates samples were collected, the number of samples collected, and the schools that were visited. Samples were collected over a four week period, June 14-July 16, 2010, from the Junior High School (JHS), the Methodist Primary School (Meth.), the Methodist Kindergarten (Meth. KG), the Presbyterian Primary School (Presby.), and the Presbyterian Kindergarten (Presby. KG). For the first week (June 14-15), 365 samples were collected from JHS and Presby. For the second week (June 21, 22, 24, and 25), 686 samples were collected from JHS, Meth., Presby., and Presby. KG. This was the first year samples were collected from kindergarten students for both the Methodist and Presbyterian schools, since permission was given by the headmasters. For Meth. KG and Presby. KG, the urine samples were screened only for microhematuria. For JHS, Meth., and Presby. the urine samples were screened for both microhematuria and eggs. For the third week (July 02), 64 samples were collected from Presby. and Presby. KG. For the last week (July 14-16), 663 samples were collected primarily from Meth. KG and absentee samples from JHS, Meth., and Presby.

Table 11. Sample collection dates, locations, and number of children screened

Date	06.14	06.15	06.21	06.22	06.24	06.25	07.02	07.13	07.14	07.15	07.16
Number of Students	188	177	180	186	168	152	64	191	238	169	65
Schools Visited	JHS	Presby.	JHS Meth. Presby.	Presby.	JHS Meth.	Presby.	Presby. Presby. KG	JHS Meth.	Presby. Presby. KG	JHS Meth. Presby.	JHS Meth. Presby. Meth. KG

Figure 30 shows the age distribution of the students screened. The outline of the graph is similar to a normal distribution graph, with most students that have similar ages consolidated in the middle and outliers that are at either ends. The age range is from 3 to 22 years old, which represents the ages of the student population screened from kindergarten to JHS. The most common ages were 6, 9, 11, and 15.

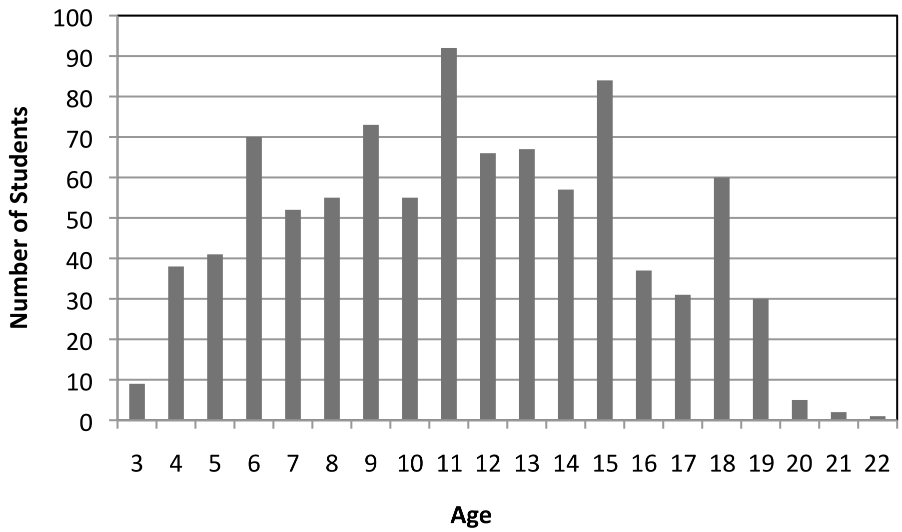

Figure 30. Age distribution of students screened

Table 12 shows the JHS student demographics. There were a total of 77 JHS students screened. The distribution of females and males in the two forms and the average age for each form is shown. Thirty-two students were surveyed with the KAP survey and 16 students were new to Adasawase as of 2010.

Table 12. JHS student demographics

JHS (n=77)	Sex	Form 1	Avg. Age	Form 2	Avg. Age	Total	Interviewed	New to Town
	Female	17	15	15	16	32	10	4
	Male	29	15	16	17	45	12	12

Table 13, shows the Methodist Primary School student demographics. There were a total of 162 Methodist Primary School students screened. The distribution of females and males from class 1 to 6 and the average age for each class is shown. Twenty-six students were surveyed with the KAP survey and 45 students were new to Adasawase as of 2010.

Table 13. Methodist Primary School student demographics

	Sex	Avg. Age	Total	Interviewed	New to Town
Class 1 (n=59)	Female	8	26	0	12
	Male	8	33	1	23
Class 2 (n=19)	Female	10	13	0	2
	Male	10	6	0	0
Class 3 (n=24)	Female	11	7	2	0
	Male	11	17	3	2
Class 4 (n=25)	Female	12	10	2	1
	Male	12	15	4	2
Class 5 (n=20)	Female	13	6	4	1
	Male	14	14	3	2
Class 6 (n=15)	Female	14	7	4	0
	Male	14	8	3	0

Table 14 shows the Methodist KG student demographics. There were a total of 32 Methodist KG students screened. The distribution of females and males and the average age for each sex is shown. No students were surveyed with the KAP survey (the students were too young) and there were also no new students to Adasawase as of 2010.

Table 14. Methodist KG student demographics

Methodist KG (n=32)	Sex	Total	Avg. Age	Interviewed	New to Town
	Female	21	7	0	0
	Male	11	6	0	0

Table 15 shows the Presbyterian Primary School student demographics. There were a total of 204 Methodist Primary School students screened. The distribution of females and males from class 1 to 6 and the average age for each class is shown. Thirty-five students were surveyed with the KAP survey and 58 students were new to Adasawase as of 2010.

Table 15. Presbyterian Primary School student demographics

	Sex	Avg. Age	Total	Interviewed	New to Town
Class 1 (n=44)	Female	8	23	2	18
	Male	8	21	3	14
Class 2 (n=35)	Female	10	14	2	4
	Male	10	21	4	5
Class 3 (n=40)	Female	11	15	3	0
	Male	11	25	8	5
Class 4 (n=31)	Female	12	14	4	1
	Male	13	17	4	2
Class 5 (n=25)	Female	12	11	1	2
	Male	13	14	2	4
Class 6 (n=29)	Female	14	11	0	1
	Male	15	18	2	2

Table 16 shows the Presbyterian KG student demographics. There were a total of 149 Presbyterian KG students screened. The distribution of females and males and the average age for each sex is shown. No students were surveyed with the KAP survey (the students were too young) and there were also no new students to Adasawase as of 2010.

Table 16. Presbyterian KG student demographics

Presby. KG (n=149)	Sex	Total	Avg. Age	Interviewed	New to Town
	Female	69	5	0	0
	Male	80	5	0	0

Table 17, Table 18, and Table 19 show the results of students from JHS, Methodist Primary School, and the Presbyterian Primary School that tested positive for microhematuria or eggs on any of the sampling days. Eighteen students from JHS were blood or egg positive, which is 23% of the JHS student population. Sixteen students from Methodist Primary School were blood or egg positive, which is approximately 10% of the Methodist Primary School student population. Thirty-nine students from Presbyterian Primary School were blood or egg positive, which is 19% of the Presbyterian Primary School student population. Whether the student was new to town was also recorded to see if infection rates were associated with this factor.

Table 17. Information on JHS students that were positive for microhematuria or eggs

Form 1				Sample 1		Sample 2		Sample 3		Sample 4	
ID	Sex	Age	New to Town	Blood	Eggs	Blood	Eggs	Blood	Eggs	Blood	Eggs
JH513	Female	17	N	3	0	0	0	0	0	0	0
JH514	Female	17	N	0.5	0	0	0	0	0	0	0
JH518	Female	14	Y	0	1	0	4	0	8	0	4
JH520	Female	15	Y	2	0	1	0	0	0	0	0
JH519	Male	15	Y	2	0	0.5	0	0	0	0.5	0
JH524	Male	18	Y	0.5	2	0	0	2	6	1	12
JH529	Male	15	Y	0	0	0	3	0	0	1	0
JH532	Male	16	Y	3	1	2	7	0	0	0	0
JME12	Male	14	N	0	12	0	5	0	17	0	14
JME36	Male	15	N	0	0	0	0	0	0	0.5	0
JME62	Male	15	N	0	0	2	0	0	0	0	0
Form 2				Sample 1		Sample 2		Sample 3		Sample 4	
ID	Sex	Age	New to Town	Blood	Eggs	Blood	Eggs	Blood	Eggs	Blood	Eggs
JH139	Female	16	N	0	0	0.5	0	0	0	0	0
JH141	Female	17	N	3	0	0	0	3	0	0	0
JPR20	Female	16	N	3	0	0	0	0	0	0	0
JH132	Male	18	N	0	0	0	0	0	0	3	0
JH136	Male	19	N	0	0	0	0	0.5	0	0.5	0
JH530	Male	18	Y	0	1	0	0	0	2	0	1
JPR07	Male	15	N	0	0	0	0	0	0	1	0

Table 18. Information on Methodist Primary School students that were positive for microhematuria or eggs

Class 1			Sample 1		Sample 2		Sample 3		Sample 4	
ID	Sex	Age	Blood	Eggs	Blood	Eggs	Blood	Eggs	Blood	Eggs
ME618	Male	9	2	0	3	0	0	0	0	0
ME628	Male	9	0	1	2	0	0	0	0	0
ME632	Female	7	0	0	0	0	0	0	0	3
ME633	Female	6	0	13	1	24	0	0	0	0
ME641	Male	9	1	3	3	155	0.5	188	3	117
ME643	Male	8	0	0	0	0	0	4	1	1
ME655	Female	8	0	0	0	0	0	0	1	0
ME662	Male	8	0	0	0.5	0	0	0	0	0
MEK06	Female	9	0.5	0	0.5	0	0.5	0	1	0
Class 3			Sample 1		Sample 2		Sample 3		Sample 4	
ID	Sex	Age	Blood	Eggs	Blood	Eggs	Blood	Eggs	Blood	Eggs
ME01	Male	12	0	1	0	0	0	6	0	6
ME431	Male	10	0	0	0	0	1	0	0	0
Class 4			Sample 1		Sample 2		Sample 3		Sample 4	
ID	Sex	Age	Blood	Eggs	Blood	Eggs	Blood	Eggs	Blood	Eggs
ME621	Male	11	2	55	3	5	3	13	1	17
Class 5			Sample 1		Sample 2		Sample 3		Sample 4	
ID	Sex	Age	Blood	Eggs	Blood	Eggs	Blood	Eggs	Blood	Eggs
ME623	Female	13	0.5	15	3	1	2	0	0.5	22
ME69	Male	13	0	0	3	0	3	0	3	0
ME89	Male	12	0	0	0	0	0	0	0	3
ME94	Female	13	0	0	0	0	1	0	0	0

Table 19. Information on Presbyterian Primary School students that were positive for microhematuria or eggs

Class 1				Sample 1		Sample 2		Sample 3		Sample 4	
ID	Sex	Age	New to Town	Blood	Eggs	Blood	Eggs	Blood	Eggs	Blood	Eggs
PR346	Female	10	N	0	0	0	0	0	9	0	12
PR817	Female	7	Y	1	19	3	28	1	23	0	0
PR818	Female	6	Y	0	3	2	0	3	10	3	2
PR821	Female	7	Y	0	0	2	96	1	87	3	0
PR854	Female	6	Y	3	0	0	0	0.5	0	0	0
PR873	Female	9	Y	0.5	0	3	0	3	0	0	0
PR353	Male	9	N	0.5	0	0	0	0	0	0	0
PR819	Male	8	Y	0	0	1	0	0.5	0	0	0
PR822	Male	9	Y	0	0	0	0	0.5	0	0	0
PR823	Male	8	Y	0	14	3	21	0	0	0	0
PR825	Male	8	Y	3	0	3	0	3	0	0	0
PR831	Male	8	Y	3	59	2	0	1	0	2	0
PRPK10	Male	7	N	0.5	2	0	7	0	13	0	5
Class 2				Sample 1		Sample 2		Sample 3		Sample 4	
ID	Sex	Age	New to Town	Blood	Eggs	Blood	Eggs	Blood	Eggs	Blood	Eggs
PR838	Female	13	Y	0	0	1	0	0	0	0	0
PR859	Female	8	N	2	34	3	0	3	31	1	28
PR807	Male	10	N	1	0	3	0	3	0	3	0
PR810	Male	9	N	0	0	0	1	0	0	0	1
PR832	Male	7	Y	0	5	0	4	0.5	4	1	8
Class 3				Sample 1		Sample 2		Sample 3		Sample 4	
ID	Sex	Age	New to Town	Blood	Eggs	Blood	Eggs	Blood	Eggs	Blood	Eggs
PR101	Male	11	N	0.5	0	0	0	0	0	0	0
PR118	Male	11	N	2	24	2	38	0	41	0.5	10
PR124	Male	11	N	0	16	0	31	0.5	22	0.5	20
PR97	Male	11	N	0.5	3	0	0	0	6	0	0
Class 4				Sample 1		Sample 2		Sample 3		Sample 4	
ID	Sex	Age	New to Town	Blood	Eggs	Blood	Eggs	Blood	Eggs	Blood	Eggs
PR158	Female	13	N	0	0	0	0	0	0	0.5	0
PR857	Female	13	Y	0.5	0	1	0	2	0	0.5	0
PR127	Male	11	N	0	0	2	0	2	0	3	0
PR170	Male	14	N	0.5	2	2	2	0	0	0	0
PR327	Male	14	N	3	0	0	0	0	0	0.5	0
PR856	Male	13	Y	3	130	2	182	0	187	2	198
PR858	Male	15	Y	2	0	2	0	3	0	0.5	0
Class 5				Sample 1		Sample 2		Sample 3		Sample 4	

ID	Sex	Age	New to Town	Blood	Eggs	Blood	Eggs	Blood	Eggs	Blood	Eggs
PR150	Female	16	N	0	0	0	0	0	0	1	0
PR162	Male	13	N	0.5	16	1	0	1	0	3	21
PR164	Female	13	N	0	0	2	0	0	0	0	0
PR844	Female	11	Y	0	0	0	0	0	0	3	0
PR142	Male	12	N	0	3	0.5	16	0	26	0	5
Class 6				Sample 1		Sample 2		Sample 3		Sample 4	
ID	Sex	Age	New to Town	Blood	Eggs	Blood	Eggs	Blood	Eggs	Blood	Eggs
PR360	Female	13	N	1	0	3	0	0	0	0	0
PR372	Male	15	N	0	0	0	0	0	1	0	4
PR700	Male	15	N	0	1	0	0	0	0	1	5
PR862	Male	11	Y	0	0	0	0	0.5	0	0	0
PR871	Male	15	N	3	28	3	0	1	0	2	0

For Methodist KG, 2 out of the 32 students were positive for microhematuria; there were no new individuals from this data set that were new to Adasawase as of 2010. For Presbyterian KG, 5 out of 149 students tested positive for microhematuria; there were no new individuals from this data set that were new to Adasawase as of 2010.