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ABSTRACT

JOHN M. DEPASQUALE
Soil-Transmitted Helminths in Schoolchildren in Grand Bois Haiti: A Prevalence Study
(Under the direction of KAREN GIESEKER, FACULTY MEMBER)

This study used secondary data collected in 2006 to assess the prevalence and severity of three common soil-transmitted helminths in schoolchildren in rural, mountainous, eastern Haiti, and using a case-control design looked at age and gender as independent risk factors, and at anemia and growth failure as potential outcomes of infection. The primary aim was to determine if prevalence and severity were high enough to meet World Health Organization (WHO) population-based deworming criteria. Results do support mass deworming, but overall, indicate no correlation between the other independent variables or outcome measures with presence of disease. A secondary data set from the coastal town of Leogane, Haiti was used as a comparison population where a similar study was performed in 1996. Based on findings, recommendations will be made to Haitian health authorities.

INDEX WORDS: Soil-Transmitted Helminths, Haiti, Growth Failure, Anemia, Children, Deworming

Soil-Transmitted Helminths in Schoolchildren in Grand Bois Haiti: A Prevalence Study

By

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M.D. TEMPLE UNIVERSITY SCHOOL OF MEDICINE
B.S. PENNSYLVANIA STATE UNIVERSITY

A Thesis Submitted to the Graduate Faculty of the Georgia State University in Partial

Fulfillment of the Requirements for the Degree

MASTER OF PUBLIC HEALTH

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2007

APPROVAL PAGE

SOIL-TRANSMITTED HELMINTHS IN SCHOOLCHILDREN IN
GRAND BOIS, HAITI: A PREVALENCE STUDY

By

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The people of Grand Bois, Haiti for being an inspiring example of courage and perseverance under adverse conditions.

AUTHOR'S STATEMENT

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LIST OF ACRONYMS & ABBREVIATIONS

Term	**Explanation**
STH	Soil-Transmitted Helminths, Helminthiasis, or Helminthiases
Geo-Helminths	Used interchangeably with STH
Any STH	Represents a subject infected with any one or more of the three categories of Soil-Transmitted Helminths, namely *Ascaris*, *Trichuris*, or hookworms (either *Ancylostoma* or *Necatur*)
DALY	Disability Adjusted Life Years
YLL	Years of Life Lost
I	Incident Cases
DW	Disability Weight
L	Average duration of illness until recovery or death
WHO	World Health Organization
Haitian MOH	Haitian Ministry of Health
CI	Confidence Interval
SES	Socio-Economic Status

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Chapter I: Introduction

Background:

Soil transmitted helminthiases (STH) are conditions of poverty (Partners for Parasite Control, 2005; Stephenson, Latham, & Ottesen, 2000). They are caused, principally, by four species of nematode worms that exist for some portion of their life cycle in the external environment, especially in soil, sometimes in water, and often on the surface of low-lying garden vegetables. They predominate in tropical and subtropical climates, and in areas with poor sanitation and sewage services. The four most common worms in the nematode phylum are grouped into three categories: roundworms, whipworms, and hookworms. Roundworm infection is caused by *Ascaris lumbricoides*, whipworm by *Trichuris trichiura*, and hookworm by both *Ancylostoma duodenale* and *Necatur americanus* (Committee on Infectious Diseases: American Academy of Pediatrics, 2006). These four are responsible for the vast majority of intestinal infections caused by soil- or geo-helminths worldwide.

The United States was endemic for these infections less than a century ago, as was southern Europe and the Far East. With deworming programs, economic development, and sanitation infrastructure, the problem has largely been eliminated (Hong et al., 2006; Hotez, de Silva, Brooker, & Bethony, 2003; Kobayashi, Hara, & Kajima, 2006; Yokogawa, 1985, pp. 265-277). This is not the case in most of the rest of the world as evidenced by the fact that these pathogens affect some two billion people at

any given time (Savioli, 2004). Although STH infections have a low case fatality rate the huge numbers of those affected result in over 100,000 deaths yearly. More significantly, perhaps, is the burden these infections exact on one's lifestyle, sense of wellbeing, professional productivity, school performance, and exercise tolerance with over 700 million symptomatic patients on average worldwide (Chan, Medley, Jamison, & Bundy, 1994).

Prevalence of disease varies widely even over small geographic areas with factors such as variation in farming practices, water supply, hygiene, and sanitary facilities. China and Vietnam have regions with high prevalence of disease while certain communities in India have much lower rates due to cultural and religious prohibition of using human feces to fertilize vegetable gardens (Guerrant, 2005, p. 1259; Needham et al., 1998; Strickland, 2000, p. 733). Data exist for broad geographic areas but many gaps exist, especially in remote regions with limited access to public health researchers and services. Many unstudied areas exist throughout the world and as close to the United States as many of the islands in the Caribbean Sea. One such island is Hispaniola, a 90-minute flight southeast of Miami, lying just southeast of Cuba. Two nations occupy Hispaniola, The Republic of Haiti to the west and The Dominican Republic to the east. The Haitian Ministry of Health (MOH) has reported regional prevalence rates for soil transmitted helminths but data does not come from all areas of the country (Comite National de Sante et de Nutrition a L' Ecole, 2004). One unstudied area is the Grand Bois region of Departement de l'Ouest, or the Western state, which is located in the southern third of the country on the Dominican Republic border. It is an inland, mountainous region with poor road access and no access by air. Until the year 2000, there

was no routine medical care, and until 2006, there was no full-time physician in the region. Poverty is nearly universal; sanitation is poor; access to improved water sources nonexistent. These are all conditions that predispose to intestinal helminth infections (Hotez & Ferris, 2006). Intestinal worms passed in feces of children are seen by the children themselves, their parents, and the few health workers that visit or work in the region. In 2004 a young girl died from intestinal obstruction caused by massive *Ascaris* infection (personal communication, L. Bourgouin, MD, 2004). To date, there have been no studies of incidence, prevalence, or health consequences of STHs in the region. Without this information it is impossible to decide if intervention is needed, how much is needed, and what the nature of the intervention should be.

Research Questions:

The motivation for this study comes from verbal reports of a problem existing, and from finding nothing in the scientific literature concerning STH infections from this particular region of Haiti. An Atlanta-based non-governmental organization (NGO), *Serve*HAITI, looked at this issue in March 2006 by surveying five randomly chosen schools to determine the prevalence and intensity of STH infections. Upon completion of the survey, officers in the NGO asked this author to analyze the collected data and make recommendations based on the results (Appendix A). Specifically, the question was whether community-based deworming would be warranted, or if limited financial resources might better be spent elsewhere. From this initial request and review of the literature, several additional questions were formulated: 1) are age and gender independent risk factors for STH disease, 2) is hookworm infection associated with

anemia 3) is *Ascaris* infection associated with poor growth and development of children, and 4) what type of program could be implemented to mitigate the problem if it was found to exist to a significant degree? Lastly, data from another area of Haiti was sought for comparison. This was provided by the Centers for Disease Control and Prevention (CDC), which made available survey data collected in 1996 and published by Beach et al. in 1999 from Leogane, a small city on the southwest coast of the country. Would the prevalence of infection differ between the two study areas and, if so, could hypotheses be generated as to why this might be?

Hypotheses:

The following hypotheses were generated from the questions asked; the literature reviewed, including World Health Organization (WHO) deworming criteria; the data collected; and from discussions with the data collectors:

1) H_O: Prevalence of all soil-transmitted helminths combined is <50%

   H_A: Prevalence of all soil-transmitted helminths combined is ≥ 50%

2) H_O: Medium/High Intensity of any soil-transmitted helminth is <10%

   H_A: Medium/High Intensity of any soil-transmitted helminth is ≥10%

3) H_O: STH infection is not more common in younger children (<10 years of age)

   H_A: STH infection is more common in younger children (<10 years of age)

4) H_O: Boys are no more likely than girls to be infected with STHs

   H_A: Boys are more likely to be infected with STHs

5) H_O: Anemia (Hgb≤11) is not more common in children with hookworm infection

   H_A: Anemia (Hgb≤11) is more common in children with hookworm infection

6) H_O: Height-for-Age is not decreased in children with *Ascaris* infection

   H_A: Height-for-Age is decreased in children with *Ascaris* infection

7) H_O: Weight-for-Age is not decreased in children with *Ascaris* infection

   H_A: Weight-for-Age is decreased in children with *Ascaris* infection

8) H_O: Weight-for-Height is not decreased in children with *Ascaris* infection

   H_A: Weight-for-Height is decreased in children with *Ascaris* infection

Chapter II:
Literature Review

Public Health Significance of Soil-Transmitted Helminths:

Soil-transmitted helminths are widespread in tropical and sub-tropical regions, and found to a lesser extent in temperate areas including the southeast United States, southern Europe, Central Asia, and Australia. They infect two billion people worldwide with most patients exhibiting mild or even no overt symptoms (Savioli, 2004). Case-fatality rates are low, estimated at 0.04% for *Ascaris,* 0.01% for *Trichuris*, and 0.05% for hookworm infection (*Ancylostoma* and *Necatur*)[1] but due to high prevalence worldwide, both morbidity and mortality are significant. Morbidity is estimated in over 700 million people (*Ascaris* accounting for 350 million cases, *Trichuris* for 220 million cases, and hookworm for 150 million cases), and death occurs in approximately 135,000 yearly (*Ascaris* 60,000, *Trichuris* 10,000, and hookworms 65,000) (Chan, Medley, Jamison, & Bundy, 1994; Savioli, 2004). Estimates of prevalence, morbidity, and mortality have not been updated in the past decade as mentioned in many recent publications (Crompton, 1999; Montresor, Crompton, Gyorkos, & Savioli, 2002; Savioli, 2004). In addition, validity of data is uncertain as disease burden estimates are complicated by lack of reporting, disagreements on case definitions, and numerous co-morbidities contributing to clinical disease and death (Crompton, 1999).

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[1] Calculated by author from data reported by Savioli et al. (2004) p. 104

One measure of disease burden useful in the study of intestinal helminthiases is the Disability Adjusted Life Year (DALY) (Montresor, Awasthi, & Crompton, 2003). This measure takes into account both the years of life lost and healthy years lost due a particular condition in a given population. It is expressed arithmetically by the following formula: DALY = YLL + YLD

Where YLL = Years of Life Lost and YLD = Years Lost due to Disability for incident cases of a particular condition. YLL in turn is determined by two factors and is expressed as: YLL = N x L

Where N = Number of Deaths due to condition in given population and L = Standard Life Expectancy at age of death in years.

YLD in turn is further described as follows: YLD = I x DW x L

Where I = Number of incident cases, DW = disability weight (or severity of disability), and L= average duration of illness until recovery or death (Prus-Ustun, Mathers, Corvalan, & Woodward, 2003). Measuring DALYs is useful in STH infections because it takes into account the large number of incident cases of disease worldwide; the long duration of infection; the degree of disability including growth failure, intellectual impairment, and anemia; and the small case fatality rate. To illustrate, in the five to 14 year-old age group these infections result in 16.7 million DALYs, which is more than the childhood cluster of pertussis-poliomyelitis-measles-tetanus, and more than tuberculosis and diarrheal diseases combined. Although total deaths and the case fatality rate are significantly lower than for malaria, STH infection is responsible for more than double the DALYs attributed to malaria (World Bank, 1993). In the total population intestinal

helminthiasis account for 39 million DALYS, a major contributor to worldwide morbidity (Savioli, Albonico, Engels, & Montresor, 2004). Specifically, key reasons for the large number of DALYs is the linkage of *Ascaris* to growth stunting, *Trichuris* to decreased school performance, and hookworms to anemia.

The Causative Agents:

Three main types of nematode worms account for the bulk of STH infections: roundworms, whipworms, and hookworms. As previously stated, roundworm infection is caused by *Ascaris lumbricoides*, whipworm by *Trichuris trichiura*, and hookworm by both *Ancylostoma duodenale* and *Necatur americanus* (Committee on Infectious Diseases: American Academy of Pediatrics, 2006). From this point forward the three conditions will be referred to as *Ascaris*, *Trichuris*, and hookworms, recognizing that hookworm infection is caused by two separate species of worms. This is done for practical reasons, as it is difficult to distinguish the two species of hookworm eggs by light microscopy, both species produce essentially the same pathology, and it is the standard way to refer to this category of disease in the published literature.

Ascaris lumbricoides**:** *Ascaris* is the largest intestinal nematode and accounts for the most disease with estimates of between one billion and 1.45 billion people infected worldwide (Crompton, 1999; Guerrant, 2005, p. 1257; Strickland, 2000, pp. 345-348). Infection occurs when humans ingest fertile eggs from the soil. This occurs when children eat dirt (pica), when they touch their face or mouth with dirty hands, or when they eat unclean vegetables from the garden. The eggs hatch and larvae emerge into the small intestine. Larvae then penetrate the intestinal wall, enter the venous circulatory

system, travel to the right side of the heart, and then on to the lungs via the pulmonary artery. Next, they penetrate the alveolar lining and enter the small airways. It takes two weeks, on average, from infection to presence of larvae in the lungs. Larvae then migrate up through the pulmonary tree to the posterior pharynx, where they are swallowed. The final maturation stage takes place in the small intestine where larvae develop into adult worms which can grow up to 40 cm in length (Committee on Infectious Diseases: American Academy of Pediatrics, 2006; Guerrant, 2005, p. 1259; Melvin, Brooke, & Sadun, 1964; Strickland, 2000, p. 726). Individual adult female worms lay up to 200,000 eggs per day, which are eliminated from the body in feces and deposited onto soil to complete the life cycle. Worms do not reproduce in humans and thus, increasing the severity of infection can come only from ingesting more fertile eggs. There is a mandatory external environmental phase of the life cycle before an egg becomes fertile or infectious (Melvin et al., 1964). This usually takes about two to four weeks (Guerrant, 2005). Adult worms live up to 18 months in humans while eggs can survive many years in the soil and remain infectious (Committee on Infectious Diseases: American Academy of Pediatrics, 2006).

Most *Ascaris* infections are mild and asymptomatic. When pathology does occur, adult worms in the intestine are usually the cause. Weight loss; malnutrition; stunting; abdominal pain; poor physical fitness; and poor absorption of key nutrients including lactose, nitrogen, and vitamin A have all been attributed to intestinal ascariasis (Adams, 1994; Stephenson, 1993a, 1993b). Even in the absence of physical pathology, mild infections can result in a general sense of poor health resulting in frequent school absence, and less than peak performance in those who do attend regularly. Heavy worm

burdens can cause intellectual impairment resulting in school failure. (Drake, Jukes, Sternberg, & Bundy, 2000). Severe infections are responsible for more serious disease with complications including intestinal obstruction by a bolus of worms, volvulus or twisting of the intestine leading to necrosis, and intestinal perforation caused by worms migrating out of the intestinal lumen. Migration of worms within the intestine can lead to blockage of the bile and pancreatic ducts causing gall bladder infection and pancreatitis. Surgery may be needed to correct the intestinal pathology in these complicated cases. Surgery is often not available, however, to those living in the poorest and most remote communities.

Figure # 1: Bolus of *Ascaris*
Ruler measures 4cm in length. These worms were removed from one patient.
Photo from (Lazar, 2006)

Pathology can also occur secondary to a hypersensitivity reaction to the larval stage as it passes through the lung. This is known as Löeffler's Syndrome (Löffler, 1956). Symptoms include fever, cough, wheezing, shortness of breath, sputum and bloody sputum production, and pneumonia. Although most episodes are mild and self-resolving, wheezing and pneumonia can be severe, with symptoms lasting for weeks. This can occur in children with no previous history of allergies, asthma, or past wheezing episodes (Talmaciu, 2006).

Trichuris trichiura**:** *Trichuris*, or whipworm, is a smaller nematode with adult worms measuring 3 to 5 cm. Nine hundred million to 1.05 billion people are chronically infected (Guerrant, 2005, p. 1252; Strickland, 2000, p. 722). Infection occurs with ingestion of embryonated, or fertile, parasite eggs from soil or contaminated food products. Eggs pass through the stomach and into the lower small intestine where they hatch. Larvae emerge from the eggs, burrow into the intestinal wall, and then migrate within the mucosal layer of the intestinal lining. This is where maturation into adults takes place. Throughout their lives, adult worms remain partially embedded in the mucosal wall with just their posterior two fifths projecting into the intestinal lumen. The entire human portion of the life cycle of this STH is within the intestine, unlike both *Ascaris* and hookworms, which have more complicated cycles. The human phase of the life cycle takes approximately three months to complete and adult worms live up to several years in the intestine.

The adult female worm lays between 2000 and 6000 eggs daily which pass from the body in feces (Melvin et al., 1964). Eggs must remain in the external environment for 10 to 14 days before becoming fertile or infectious. The life cycle is complete upon

human ingestion of this new cohort of mature eggs. *Trichuris* eggs are more fragile than those of *Ascaris*, needing consistently warm and moist conditions to survive (Guerrant, 2005, p. 1252; Strickland, 2000, p. 722). Duration of egg survival thus varies greatly depending on environmental conditions.

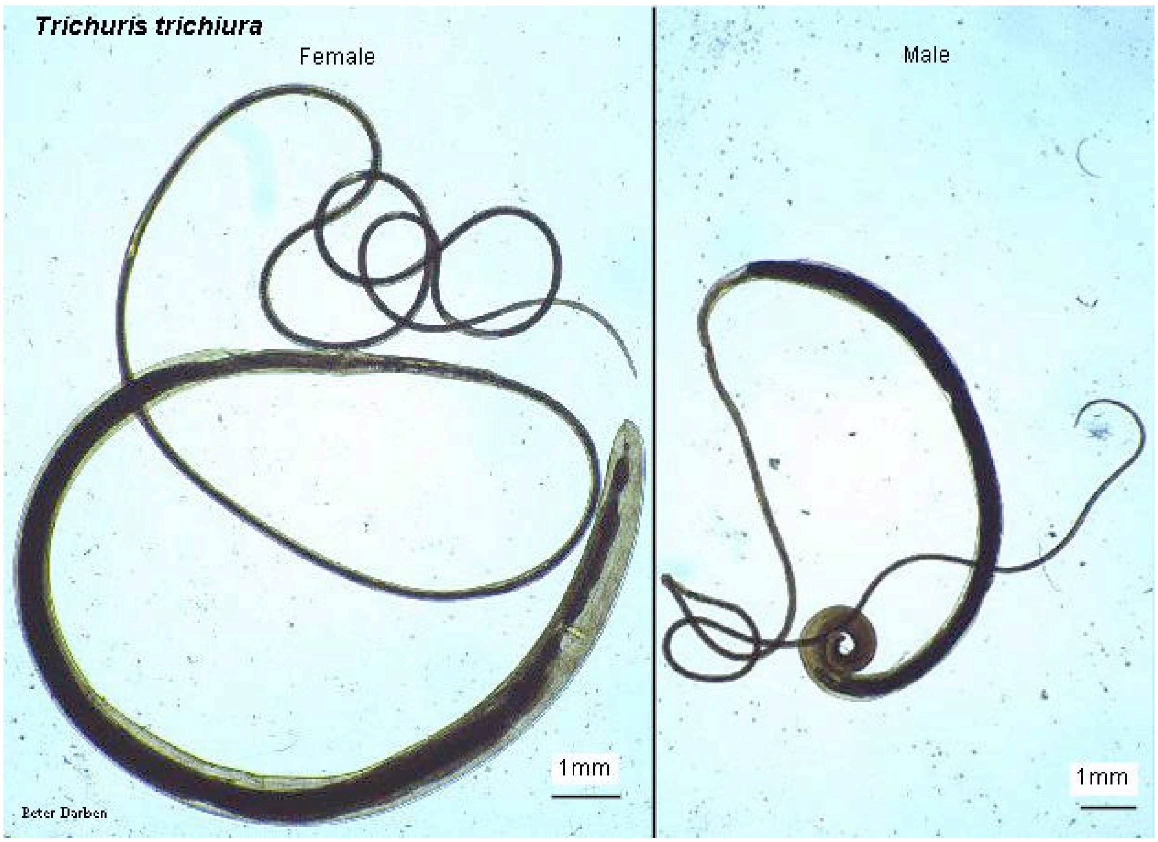
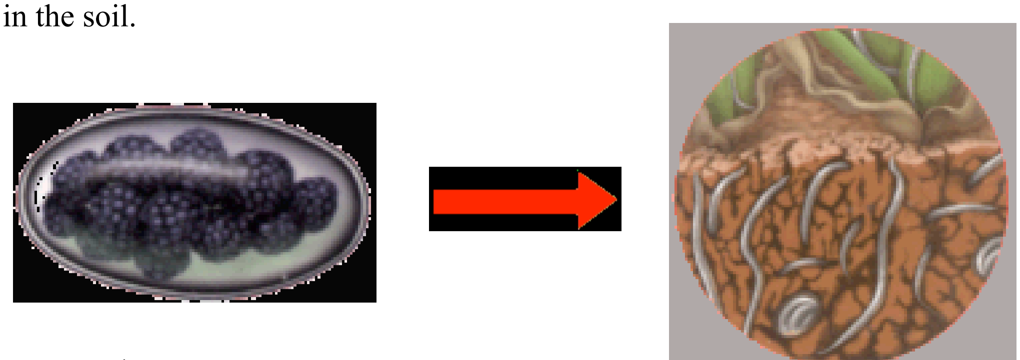


Figure # 2: Female and male adult *Trichuris* worms, easily visible with naked eye but much smaller than *Ascaris*
From (Oracle ThinkQuest Education Foundation, 2006)

Clinical conditions secondary to this infection include intestinal bleeding leading to anemia (Ramdath, Simeon, Wong, & Grantham-McGregor, 1995), abdominal pain, chronic diarrhea, rectal prolapse in those with heavy infection (Committee on Infectious Diseases: American Academy of Pediatrics, 2006), and growth retardation with

prolonged and severe infection (Cooper & Bundy, 1987; Crompton & Nesheim, 2002; Strickland, 2000, p. 723). Cognitive abilities are adversely affected in chronic and severe infections (Nokes & Bundy, 1994).

Hookworms: Hookworms are the smallest of the STHs, measuring between 0.5 and 1.3 cm in length (Strickland, 2000). They infect approximately 1.3 billion people worldwide (Crompton, 1999) with *Necatur americanus* causing more new-world infection while *Ancylostoma duodenale* predominates in Africa, Asia, the South Pacific and Australia, although much geographic overlap is seen (Guerrant, 2005, p. 1268). Unlike *Ascaris* and *Trichuris*, hookworm eggs eliminated in human stool mature in the external environment where they hatch into larvae (Figure 3). Under ideal environmental conditions this takes between five and ten days. Infection begins when larval forms from the soil penetrate human skin, often of bare feet and toes, at points of integrity compromise including cuts, scrapes, fissures, and hair follicles. Less commonly legs, buttocks, hands, and arms can be sites of entry, especially in children and those working in the soil.



Hookworm Egg Passes in Stool

Hookworm Larvae Living in Soil Just Below the Surface

Figure # 3: Hookworm Eggs and Larvae
Adapted from (Mar Vista Animal Medical Center, 2004)

After infection takes place, larvae enter the venous circulation and travel to the right side of the heart and on to the lungs where, like *Ascaris*, they break through the alveoli and into pulmonary airspaces. From here they migrate up the bronchi and trachea and into the pharynx where they are then swallowed. They enter the small intestine where they mature into adult worms. Adult worms begin laying eggs five weeks after initial skin penetration and can live in the human for five to seven years. Adult female worms pass between 10,000 and 25,000 eggs per worm per day into stools, which completes the life cycle (Guerrant, 2005, p. 1267; Melvin et al., 1964). Interestingly, studies from India reveal that in sub-optimal external environmental conditions, hookworm larva can enter dormancy and survive for a year or more before regaining infectiousness (Strickland, 2000, p. 732). The best environmental conditions for maintenance of the life cycle are warm, moist temperatures (80^0 to 90^0 F), shaded areas, and sandy or loamy (sand + clay + humus) soil. Typically, annual rainfall of 50 inches or more is optimal while drying and freezing can destroy larvae.

Clinical disease includes skin reactions to larval penetration including local dermatitis and cutaneous larva migrans, a serpiginous rash following the course of the larva as it travels within the skin before being taken up by the venous circulation. These rashes are pruritic and can become secondarily infected. As the larvae pass thru the lungs, wheezing, cough, bloody sputum, and pneumonia may occur as with *Ascaris* infection (Loeffler's Syndrome) but this tends to be mild (Committee on Infectious Diseases: American Academy of Pediatrics, 2006). Most pathology occurs secondary to adult worms in the intestines. Mild to severe abdominal pain, flatulence, diarrhea, and bloody stools are all common with moderate to heavy infections. In the most severe

cases intestinal perforation leading to massive uncontrolled intestinal bleeding may occur and lead rapidly to death, especially in young children (Committee on Infectious Diseases: American Academy of Pediatrics, 2006; Guerrant, 2005; Strickland, 2000).

Anemia is the classic presentation of hookworm disease. Adult worms attach to intestinal mucosa with sharp cutting plates and release anticoagulant factors which aid in the continual ingestion of blood, the primary nutrient for these nematodes (Furmidge, Horm, & Pritchard, 1995). In addition, some blood seeps from the mucosal wounds, around the worms, and is lost directly into the intestinal lumen. In heavy infections in children and women with marginal iron stores, hemoglobin levels can drop to 25% of normal over a period of months to years (Strickland, 2000, p. 734). This severe degree of anemia affects every aspect of well being resulting in weakness, malaise, decreased work output, decreased school performance, poor exercise tolerance, poor growth and physical development, and depression. Physically, the patient looks pale, has finger and toe nail changes (koilonychia), and oral mucosal inflammation. In severe cases, shortness of breath, heart palpitations, rapid heart rate, heart murmurs, edema of extremities, and outright heart failure may occur. Risks are especially high in infants, pregnant women with severe degrees of anemia, and developing fetuses (Committee on Infectious Diseases: American Academy of Pediatrics, 2006; Sen-Hai, Ze-Xiao, & Long-Qi, 1995; Strickland, 2000, p. 734).

In summary, these three infections are diseases of poverty and poor sanitation with highest prevalence in warm moist climates. Helminths do not reproduce in the body but require an external environmental stage to complete their life cycles. Adult worm infestations can persist for months to many years, even in the absence of re-infection, and

eggs and larva can survive in the environment for weeks to months to many years depending on the species and the environmental conditions. These facts play into the epidemiology and have significant ramifications for prevention and control programs. Of note, all three infections may cause some degree of physical growth retardation, which may lead to trans-generational health problems in a cycle that will persist without specific intervention (Figure 4).

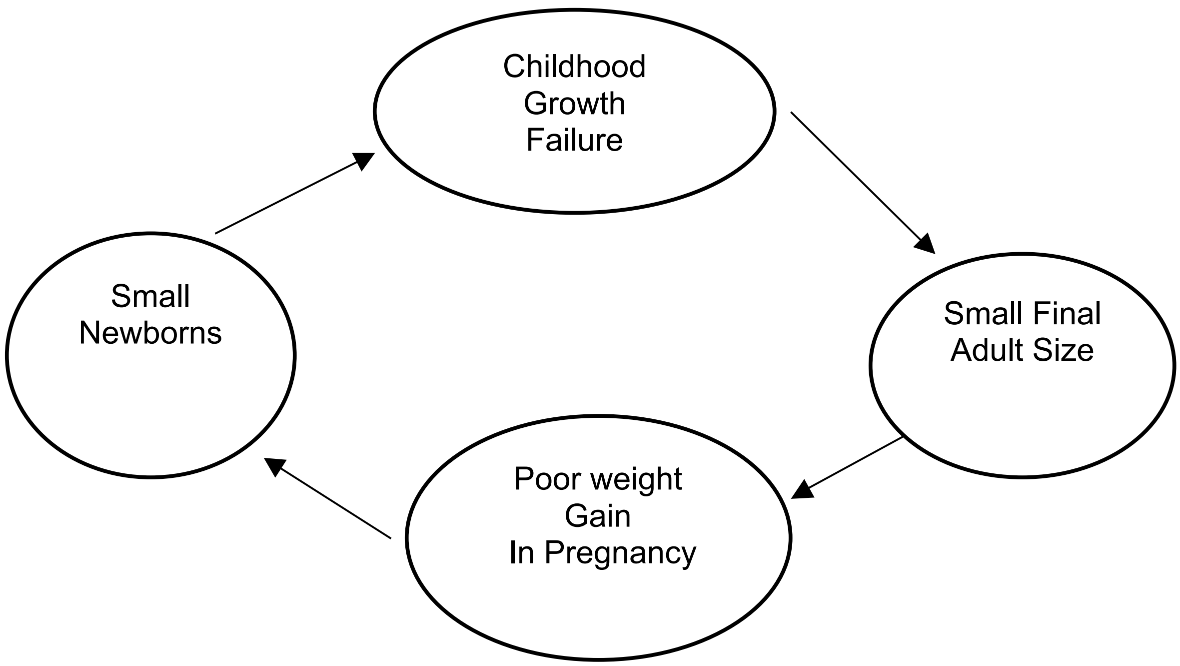


Figure # 4: Trans-generational Effects of Intestinal Helminthiases
Adapted from (Ottesen & Campbell, 1994)

World Health Organization: Primary and Secondary Prevention Through Mass Anthelminthic Treatment (Deworming)

Secondary prevention is achieved through medicinal treatment of children and adults with the goal of decreasing morbidity and mortality. This occurs by decreasing worm burden, which decreases the incidence of complications like intestinal obstruction in those with *Ascaris* infection. In addition, studies have shown treatment can result in better nutritional status, improved growth, better school attendance and performance, resolution of anemia, improved birth outcomes, and improved work capacity (Adams, 1994; Drake et al., 2000; Stephenson, 1993a, 1993b). These benefits can be seen in relatively short periods of time and do not require total elimination of the worm population from the patient. Any reduction in intensity of infection can be beneficial. Demonstration of the cognitive improvement has been shown in Jamaica and Kenya (Ashwathi, 2000; Partners for Parasite Control, 2005). Current research is looking at potential benefits in reducing the severity of concomitant tropical diseases like tuberculosis, malaria, HIVAIDS and others (Fincham, 2003; Speigel, 2003).

Primary prevention is achieved over a longer period of time and involves a reduction in the incidence of infection. This is achieved because as deworming takes place, fewer individuals have heavy-burden disease. They therefore eliminate stools with fewer helminth eggs, and thus fewer eggs enter the environment. With fewer eggs in the soil the acquisition of infection is reduced, even with no change in hygiene or sanitary practices. As previously noted, this benefit may not be longstanding if anthelminthic medications are stopped.

The WHO has taken the lead in global deworming efforts, publishing expert reports, clinical guides, laboratory guides, and educational manuals for teachers, program administrators, and public health workers (Montresor, 2004; Montresor et al., 2003; Montresor et al., 2002; Montresor, Crompton, Hall, Bundy, & Savioli, 1998; Partners for Parasite Control, 2005; World Health Organization, 1991, 1994, 2002, 2003, 2004, 2005). See appendices D through G for sample forms provided by the WHO to register and follow children in a school-based deworming program (Montresor et al., 2002). Programs using these guidelines and aids have proven to be clinically effective, cost effective, safe in multiple settings in developing nations, and relatively simple to administer (World Health Organization, 2002, 2004).

Pharmacotherapy is the mainstay of all control programs as immunotherapy is only in the earliest phases of development (Hotez & Ferris, 2006), and infrastructure improvement is considered a costly long-term goal. Education on basic hygiene, sanitation, and basic helminth disease biology is included in many programs. Basically, the WHO goals include conducting prevalence studies aimed at grade school children because they are easy to reach, cooperative with providing stool samples, and usually have the highest prevalence of disease in the community. Recommendations are for randomly sampling five schools, with 50 children from each school for a total of 250 students tested. This is considered representative of the surrounding region if the climate and terrain are similar between schools. The specific equipment and techniques of testing are discussed in the methodology section as they were used in performing the Grand Bois survey. Upon completion of survey, all participants are offered anthelmminthic therapy with albendazole or mebendazole, which is consistent with the WHO philosophy of "no

survey without service". Analysis of results is performed to determine the prevalence and intensity of infection and this information is used to determine if school-based mass treatment is needed, and if so, how frequently. Specifics will be addressed in methodology and discussion sections as they pertain to both Grand Bois and Leogane surveys.

Certain aspects of prevention programs bear further comment. First, care in choosing communities to deworm is warranted to prevent overuse of medications with resultant development of resistance (Savioli, 2004). Second, in the past, the mainstays of treatment, albendazole and mebendazole, have not been used in pregnant women and children under two years of age. Over the past five years this practice has changed with new studies indicating safety in these groups (Urbani & Albonico, 2003; World Health Organization, 2003). This is encouraging as the medications are effective, inexpensive, and young children and pregnant women are particularly at risk for serious sequelae to helminthic infections (Savioli, 2003). Third, cost of medications, including transport and insurance, is approximately 2-4 cents per dose, and thus, chemotherapy is considered the most economically efficient intervention program at this time for dealing with helminthiases in many areas of the world. Adding the administrative costs of training, monitoring, and supplying educational materials, estimate of total cost is 34 cents per year per child treated. This has been shown to be the case in many nations, including in the Americas (Partners for Parasite Control, 2005; Sebastian & Santi, 2000). Lastly, the WHO has set a goal to treat 75% of those communities needing deworming by the year 2010 (Partners for Parasite Control, 2005).

Soil-Transmitted Helminthiases in the Americas: Examples of Prevalence Studies and Deworming Efforts

Soil-transmitted helminths, also known as geo-helminths, are widely but unevenly distributed in tropical regions of the western hemisphere including on Caribbean islands where poverty and poor sanitation predominate. Prevalence of STH infections has been reported for regions in Mexico, Columbia, Nicaragua, and the islands nations of Martinique and Jamaica, and these infections have been associated with growth failure, anemia, and intellectual impairment just as they have in Africa and Asia (Hadju, Abadi, & Stephenson, 1995; Magnaval, 1998; Oberhelman, Guerrero, & Fernandez, 1998; Ordonez & Angulo, 2002; Quihui-Cota, Valencia, & Crompton, 2004). Twenty years ago Bundy called for a reappraisal of prevalences and severity of *Trichuris* infection throughout the Caribbean as under-reporting and under-appreciation of the effects of this infection were rampant (1986). Up until that time it was believed that *Ascaris* was the primary STH causing disease in the region. Since that time various nations have performed studies showing *Trichuris* to be a major contributor to prevalence but of uncertain importance as a contributor to morbidity (Bundy, 1986; Bundy, Cooper, Thompson, Didier, & Simmons, 1987; Henry, 1988; Montenegro & Stephens, 2006). No single-source regional database has been developed which reports on STH infections.

On the island of St. Lucia, Bundy et al. in 1987 reported *Trichuris* and *Ascaris* to have similar prevalence, but *Trichuris* to have a greater reproductive rate than *Ascaris*, thus making it potentially more difficult to control. In part, this may explain why *Trichuris* infections remained at higher levels into adulthood while *Ascaris* infection

peaked in the early school years and declined in adolescence and adulthood. Re-infection rates were high 18 months after treatment with anthelminthic medication, with the most highly infected subjects before treatment reacquiring infection at equally high levels in the post-treatment period. Consistent with most studies, it was found that few people were highly infected while most were mildly infected. This was true regardless of the age of subjects (Bundy et al., 1987). Lastly, through statistical modeling of frequency distributions, it was suggested that when large differences in *Trichuris* prevalence between communities are noted, it is most likely due to environmental factors and not intrinsic susceptibility differences of those infected or of worm virulence factors (Bundy et al., 1987).

In 2002, Boia et al. conducted a cross-sectional study in the remote Amazon-Basin town of Santa Isabel do Rio Negro, Brazil. It has just over 4,000 residents, of whom 308 children and adults were tested for the presence of STH eggs in stool. Analysis was performed with the commercially available Coprotest kit which uses a modified Ritchie stool concentration technique (Young, Bullock, Melvin, & Spruill, 1970). Results indicated that the area is endemic for *Ascaris*, *Trichuris* and hookworms with 48%, 27%, and 21% prevalence respectively (Boia et al., 2006). Factors increasing likelihood of infection included belonging to a family with no cash generating activities, and living in a home with no latrine. Almost half (48%) of families enrolled in the study had improved sources of water in the home but there was no mention of this being related to prevalence of disease.

Twelve months following the survey, mass deworming was conducted with the administration of albendazole to 83% of the non-pregnant townspeople over one year of

age. Researchers followed WHO Expert Committee Report guidelines in conducting the study (World Health Organization, 2005). This was the first known community-wide attempt at STH treatment and control in Brazil. Twelve months post-treatment, a second survey was conducted which revealed significant decreases in prevalence of all three worms types and decrease in polyparasitism, or infection with more than one type of worm at time of screening. This was achieved with only one course of treatment and significant reductions in worm counts lasted for at least one year (Boia et al., 2006). Intensity of infection was not assessed and long-term follow-up has not yet been reported. Consistent with much of the public health literature and WHO committee reports on helminths, authors conclude that improved infrastructure and education programs are needed to maintain improvements in the absence of routine anthelminthic treatments.

In 2002, Champetier de Ribes et al conducted the first nationwide study of geohelminths in school children in all ten departments or states in Haiti (2005). Urban and rural regions were selected using a cluster sampling method where geographic areas instead of individuals were randomized (Cottrell & McKenzie, 2005, pp. 121, 124-125). Stool samples from 5,792 students, aged 3 to 20 years, from 26 urban and 49 rural schools, were collected and preserved. Using the Ritchie laboratory technique the presence or absence of helminths was established (Weber, Bryan, & Juranek, 1992). Subsequently, the Haitian MOH reported these findings in a government health report and is currently using them as baseline data on which to conduct mass deworming (Comite National de Sante et de Nutrition a L' Ecole, 2004). Overall, 34% of stools tested positive for soil transmitted helminths with the following breakdown: *Ascaris* (27.3%), *Trichuris* (7.3%), *Necatur* (hookworm) (3.8%), and three other species to a

lesser degree. Prevalence was higher in rural areas (38.4%) than in urban settings (30%). No statistically significant differences were noted based on age or gender. Intensity of infection was not reported (Champetier de Ribes et al., 2005). The prevalence by department is listed below in Table # 1.

Table # 1 Nationwide Prevalence of Any STH in Haiti

Department	**Prevalence**
Nord Ouest	38%
Nord	46%
Nord Est	25%
Artibonite	33%
Centre	21%
Ouest	25%
Sud Est	28%
Nippes	26%
Sud	26%
Grande Anse	74%

Based on results, authors concluded that mass deworming of Haitian schoolchildren with albendazole is advised, with the frequency of administration dependent on prevalence of infection in given regions. The study, however, reported prevalence data for both urban and rural districts in most, but not all, departments of Haiti. The rural regions of Departement de l'Ouest, the location of Grand Bois, were not studied. Lastly, no

correlations of prevalence or intensity of infection with growth failure, anemia, or school performance were reported in this nationwide study.

The results of this study have been used by the Haitian MOH to initiate control and treatment programs. Grand Anse, in the extreme southwest corner of the country, has been a target for government deworming efforts because of its extremely high prevalence rates. In a 2006 update of the Haitian MOH publication on helminthiasis they report 85% of preschool children treated with albendazole in 2004 and 100% treated in 2005. In contrast, the Departement de l' Ouest had only 18% coverage in 2004 and 23% in 2005. Anthelminthic coverage is not uniform, with potentially large usage gaps in remote areas where prevalence data is missing. Nationwide, over 700,000 doses of albendazole were distributed in 2005, up from just over 100,000 in 2004 (Comite National de Sante et de Nutrition a L' Ecole, 2006). The WHO set a goal of routine treatment of 75% of vulnerable children by the year 2010 (Partners for Parasite Control, 2005, p. 15). Haiti has reached this goal in some areas of the country, but sustainability and expansion of their efforts is key to achieving lasting results.

Mass deworming has proven safe and effective in the Leogane region of Haiti as reported by de Rochars et al in 2004 and 2007. As part of a larger program to eliminate lymphatic filariasis, albendazole was initially administered to about 1,000 persons in two rounds over two years at sentinel sites and then expanded to 100,000 subjects over the next six years. Stool was studied before the first dose and reexamined 9 months after the second dose was administered. Before treatment, *Ascaris*, *Trichuris*, and hookworm prevalences were 20.9%, 34%, and 11.2% respectively. Post treatment prevalences were decreased to 14.1%, 14.6%, and 2.0% respectively, and severity of infections was

reduced as well (de Rochars et al., 2004). This program was based on the CDC data collected in Leogane in 1996 that is also the data set used in this thesis as a comparison group to the Grand Bois primary data set. This model of piggy backing deworming programs onto other existing programs has proven effective around the world, adding it to Vitamin A supplementation, and schistosomisasis and lymphatic filariasis treatment and control programs, for example (Montresor, 2004). Also, integrating it with school health and immunization programs has been administratively feasible and cost effective (Partners for Parasite Control, 2005, p. 16).

The Two Study Regions in Haiti:

The research questions and hypotheses will be addressed for the two regions from which data was made available, Grand Bois and Leogane. Both regions, along with the capitol city of Port-au-Prince are located in the same political department or state (Departement de l'Ouest), which encompasses coastal, remote mountainous, and major urban sectors. Grand Bois and Leogane differ from each other in many ways including terrain, weather, proximity to the sea, per capita income, access to medical care, and access to Port-au-Prince (Table 2).

Table 2: Comparison of Study Sites

	Grand Bois Region	Town of Leogane
Terrain	Mountainous	Lowland Plains
Soil Type	Sandy	Loamy
Location	Inland	Coastal
Distance from Port-au-Prince	75 km, 6-12 hour drive	30 km, 1-1.5 hour drive
Elevation	2700-4000 ft	68 ft
Type	Rural	Small Urban
Population[2]	65,000 (dispersed)	15,000 (concentrated)
Climate	Semi-arid 2 rainy seasons	Semi-arid 2 rainy seasons
Temperature	Warm days, Cold winter nights, low temps: 40^{O}F	Hot days, Warm winter nights, low temps 70^{O}F
Health Facilities	6 bed clinic	150 bed Hospital
Schools Surveyed	Five, widely separated geographically and by services	Five, closely approximated geographically, similar terrain, and services
Per capita Income[3] In US Dollars	262	650

[2] (Ministere De L' Economie Et Des Finances, 2000b)
[3] (Ministere De L' Economie Et Des Finances, 2000a)

The following maps and satellite photos show the country of Haiti, the Departemente de l'Ouest, and the regions of Grand Bois and Leogane:

Figure # 5: Haiti and the Caribbean Sea
Haiti with the Dominican Republic and Cuba (Central Intelligence Agency, 2006)

Figure # 6: Departement de l’ Ouest, Haiti
Departement de l’Ouest extending from the Caribbean Sea in the west to the high mountains bordering the Dominican Republic to the east (Mapzones.com, 2002).

As noted in Table 2, geographical and topological differences exist between the two regions despite being separated by only a little over one hundred kilometers. This is exhibited in the following satellite photos:

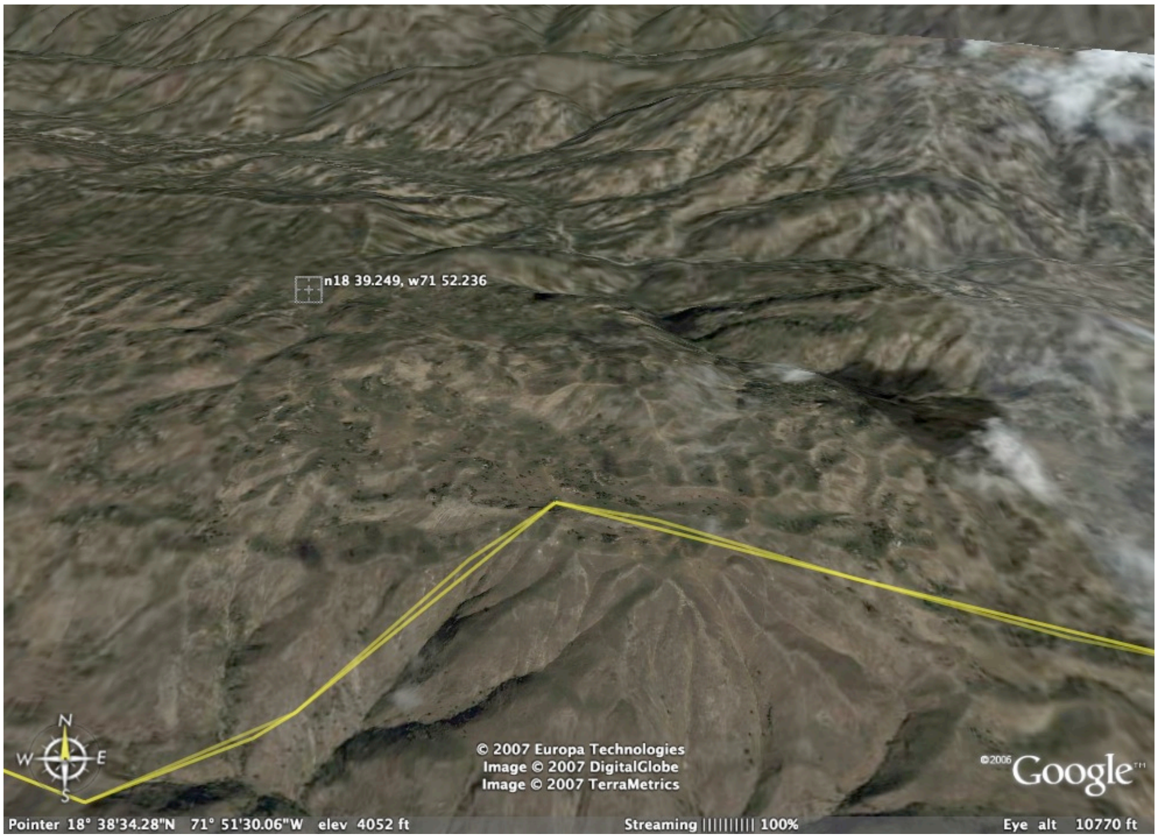


Figure # 7: Grand Bois, Haiti

This satellite photograph shows the Grand Bois region from 10,770 feet above the earth's surface with town of St. Pierre marked with a square icon and latitude and longitude values. The yellow line indicates location of border with the Dominican Republic to the south (Google Earth, 2007). This illustrates the extreme remoteness, deforestation, and mountainous terrain of the area.

Figure # 8: Leogane, Haiti with Caribbean Sea to the northwest
This satellite photograph shows the flatness of the Leogane urban area from 7356 feet above the earth's surface (Google Earth, 2007). It has a more highly developed agricultural economy, more tree cover, and more infrastructure, including a network of roadways which is lacking in Grand Bois.

Chapter III: Methods

Study Description

This study is a secondary analysis of two data sets. The data set of principal interest is data that was collected by a joint US/Haitian medical team working with the Atlanta-based NGO *Serve*HAITI. The second set is from a previously published CDC Parasitic Diseases Branch study in Leogane, Haiti, which has been made available in the public domain for further analysis.

*Serve*Haiti data was collected in the Grand Bois region of eastern Haiti and will henceforth be referred to as the "Grand Bois study". Data was collected in late March of 2006 and has not previously been analyzed. Appendix A is a letter from the researchers and executive director of *Serve*HAITI asking for help with analysis and guidance on recommendations. Approval to perform this secondary data analysis was granted by the Georgia State University Institutional Review Board. In addition to supplying the data set, researchers shared their observations of the region, methodology used, and difficulties with the study. The bulk of this section will concentrate on their efforts in Grand Bois with somewhat less attention paid to the details of the 1996 CDC Leogane study (henceforth, "Leogane study").

Grand Bois Study: Prior to conducting the Grand Bois study, school, public health, and medical personnel verified that no mass deworming programs had taken place

in the region or in any school over the previous six years. Individual patients however, with known history of intestinal helminthiasis, were treated with anthelminthics, as needed. With the help of local officials, the 15 largest primary schools were identified within a one-day walk of study headquarters in La Pointe, Grand Bois, and five were randomly selected as study sites. Figure 9 shows Departement de l'Ouest with the Grand Bois region circled in yellow. Figure 10 shows the greater Grand Bois region expanded from its location in Departement de l'Ouest, and Figure 11 is the further expanded southeast portion of Grand Bois with the locations of the five schools selected as survey sites and the medical center in La Pointe identified.

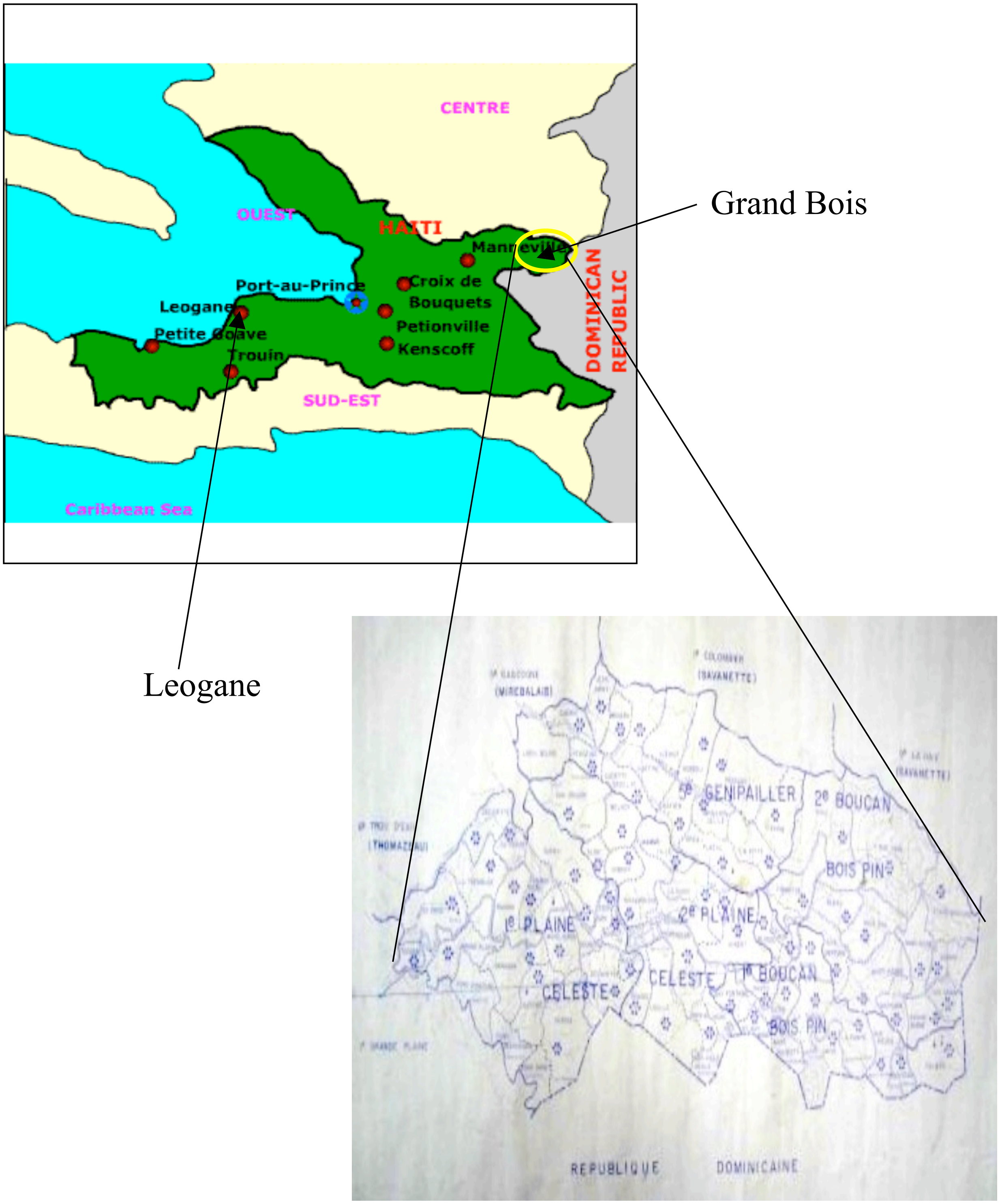


Figure 9: Upper Map, Departement Ouest, Haiti, which includes both Leogane and Grand Bois. Figure 10: Lower Map, The Greater Grand Bois Region
Figure # 9: from (Mapzones.com, 2002)
Figure # 10: Digital photograph of only known map of Grand Bois, circa, 1970 by Lizbeth McDermott, and Art Judy, March 2006, Courtesy of *Serve*HAITI.

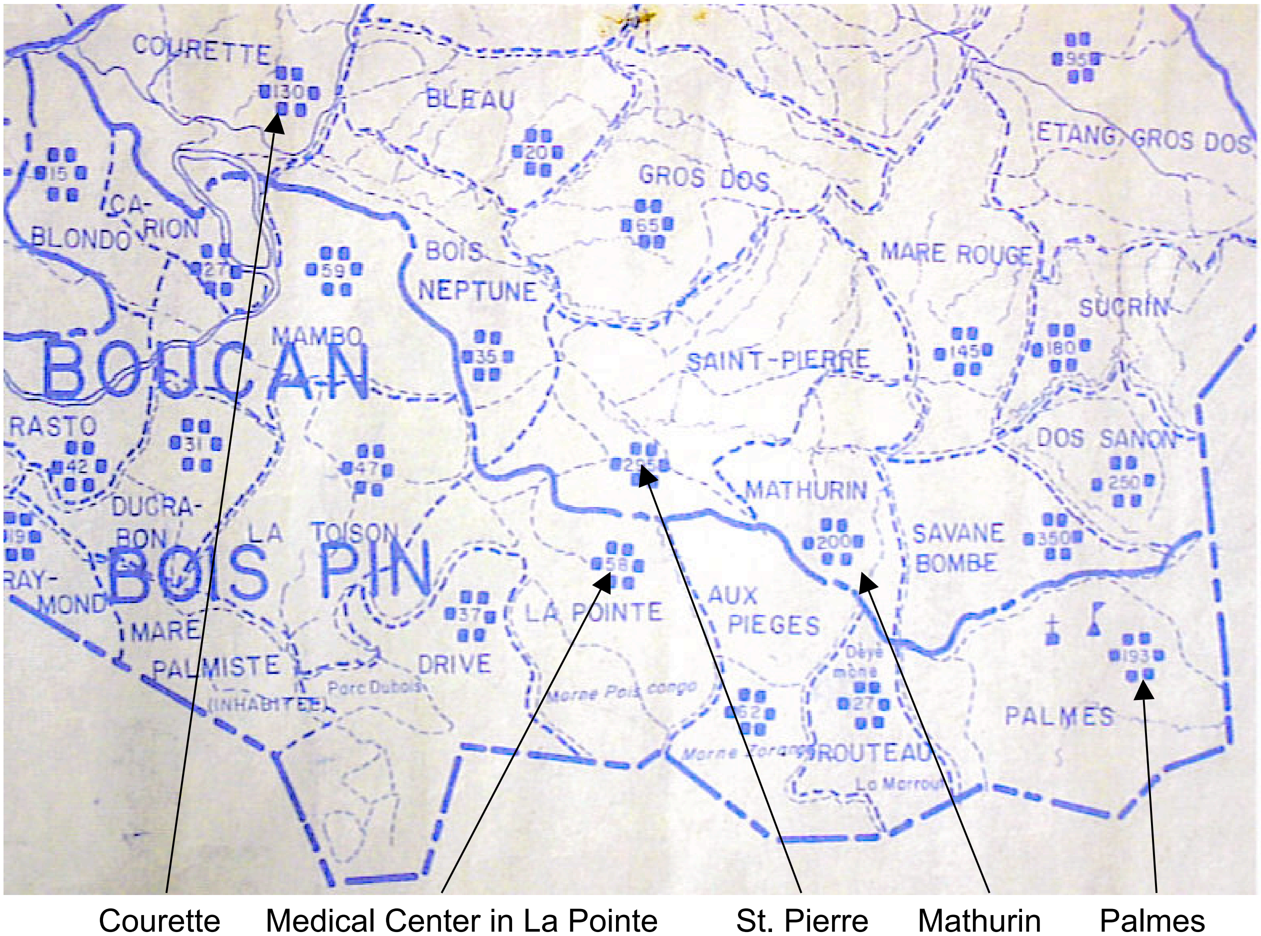


Figure 11: Close-up of four towns where five survey schools were located, plus location of the St. Vincent de Paul Medical Center, the only continuously operated health care facility in the region. This maps represents the southeast corner of Grand Bois (Figure # 10 above)
Digital photograph of only known map of Grand Bois, circa, 1970 by Lizbeth McDermott, and Art Judy, March 2006, Courtesy of *Serve*HAITI.

The five schools are all located in remote rural areas of Haiti. Two of the schools are located in St. Pierre, one of the largest population and market centers in the region, and one school each in Courette, Mathurin, and Palmes. There is no electricity, improved water source, or municipal sanitation service at any of the schools or in the surrounding residential areas. The four sites share similar climate and geography. Most parents work

as subsistence farmers and children attend school when families are able to afford tuition and fees. Attendance therefore tends to be intermittent and teens up to 18 years of age will occasionally still attend primary school. A brief description and comparison of the five sites is presented in Table 3 below.

Table 3: Description of School Survey Sites in Grand Bois

School (L' Ecole)	Elevation in Feet	Water Supply: Type	Water Supply: Proximity to School	Latrine Facilities at School	Distance To Health Clinic
# 1, L' Ecole Nationale, Mathurin	3800	Intermittent Stream	One hour walk in rainy season	No	3 hour walk
#2, L' Ecole Presyterale, St. Pierre	3031	Cistern, Springs, Stream	Minutes walk	Yes	30 minute walk
#3, L' Ecole Nationale, Les Palmes	3600	Intermittent Stream	One hour difficult walk in rainy season	No	3 hour walk
#4, L' Ecole Baptiste, Courette	2797	Intermittent Stream	One hour difficult walk in rainy season	Yes	3 hour walk
#5, L' Ecole Baptiste, St. Pierre	3031	Cistern, Springs, Stream	Minutes walk	Yes	30 minute walk
SVDP Health Center[1]	3674	Cistern	***	Yes	***

All children from each school were invited to participate with a goal of recruiting 50 students from each school. At each school students were enrolled as they presented to

[1] SVDP = St. Vincent de Paul Health Center

the team until the desired number was reached, resulting in randomization at the geographic but not the individual level. This is consistent with a cluster design of selecting subjects (Cottrell & McKenzie, 2005). Criteria for inclusion in the study included, enrollment in the randomly selected school; collection of both blood and stool specimens; and obtaining, height, weight, and age for each participant. If class size is large enough, the WHO recommends enrollment of all students in one randomly selected third grade class. If this does not provide researchers with adequate subjects then selecting additional classes is suggested (Montresor, Crompton, Gyorkos, & Savioli, 2002). Such was the case in each of the Grand Bois schools selected, as usually the entire school is broken down into only a few separate classes or grades.

After choosing the schools and establishing selection criteria, verbal consent was obtained from school principals, teachers, and parents; and verbal assent was obtained from all children over 6 years of age. Of 229 initial enrollees a final group of 226 were selected for analysis and three were eliminated due to missing stool data. Data collected included patient identifiers, name of school, region of habitation, age in years, weight in kilograms, height in centimeters, stool specimens for soil-transmitted helminth egg counts, and hemoglobin levels from finger stick specimens of blood. No patient identifiers were provided to this researcher. Methodology for this study closely followed that outlined in " Helminth Control in School-age Children: A Guide for Managers of Control Programmes" (Montresor et al., 2002).

Heights were obtained using a measuring tape superimposed on a "Tablet Pole", provided by the WHO in their program guide materials (Montresor et al., 2002). This provided a wide, sturdy device for use in the field. Heights were measured to the nearest

0.5 centimeters. Weights were obtained using a Health-O-Meter digital scale (Sunbeam Products Inc, Boca Raton, FL, model HDL 200-05) and measured to the nearest 0.1 kilogram. Both height and weight measurements were taken with children wearing clothing but no shoes. Stool specimens were collected on the day of the study at the schools and analyzed using the Kato-Katz technique (Idris & Al-Jabri, 2001). Finger stick blood specimens were analyzed using the Haemoglobin Colour Scale (developed by the WHO and distributed by Copack GmbH, Denmark), a colorometric blood analyzer accurate to the nearest 1.0 gram per deciliter (gm/dl) (Critchley & Bates, 2004; Lewis, 1998). All results were recorded on standard WHO reporting forms (Montresor et al., 2002). Appendices D through G show examples of reporting forms used in this and many other similar studies.

The Kato-Katz thick smear technique (Idris & Al-Jabri, 2001; World Health Organization, 1991, 1994) was used to determine the prevalence and intensity of intestinal helminth eggs in stool. It uses a fixed quantity of fecal material from each patient which is measurable in the field using commercially available diagnostic filter kits (Vestergaard Frandsen, Disease Control Textiles, Denmark) (2007). It is an indirect method to assess worm burden in that it estimates the burden of infection with female worms only as they are the source of eggs. The higher the egg count, the higher the worm burden in most individuals (Idris & Al-Jabri, 2001; Santos, Cerqueira, & Soares, 2005). Slide preparation and analysis were done in the field and completed within four hours of obtaining the specimen and within one hour of preparing slides. Delay in this procedure can result in under-estimating the prevalence of hookworm eggs, as they are easily degraded under adverse environmental conditions and thus difficult to identify with

microscopy. Appendices B and C provide an outline of the Kato-Katz technique as outlined by the WHO (Montresor et al., 2002; Vestergaard Frandsen, 2007). It requires no high-technology medical equipment other than a battery-operated light microscope (Meiji 104-LED was used) and is therefore well suited to remote area studies (MicroscopeWorld, 2007). Kato-Katz analysis permits measurement or calculation of the number of *Ascaris*, *Trichuris*, and hookworm eggs per slide, the number of eggs per gram of stool, and whether the child had light, moderate, or heavy infection. Specific criteria for the three intensity categories will be discussed in upcoming, Method of Analysis section. Figure # 12 shows the primitive setting within a school that can be used to perform this analysis.

Figure # 12: Field Laboratory inside school at Mathurin, Grand Bois, Haiti with team-lead and laboratory technician analyzing specimens using Kato-Katz technique. Photo courtesy of *Serve*HAITI, March 2006

After stool and blood specimens were obtained and measurements taken, each child was treated with mebendazole 500mg before any analysis was completed on the stools. This is consistent with WHO recommendations for helminth surveys that all participants should receive some benefit for their participation. Medications are considered safe enough to give even to those with no documented infection, as would be case for many in a mass deworming program (Urbani & Albonico, 2003; World Health Organization, 2003). Side effects consist largely of mild abdominal cramping when

children are heavily infected, transient headaches, and very rare allergic reactions (Strickland, 2000, p. 729).

Figures 13 and 14 show the remoteness of the area and the rudimentary sanitation facilities typically seen in schools and homes in Grand Bois. No site pictures are available for the Leogane schools or community.

Figure 13: Mathurin, Grand Bois, Haiti
School at Mathurin to the right; abandoned, partially built, "new" school, without roof, to the left. Location is at high elevation, with no close sources of water for washing, drinking, cooking, hygiene, or sanitation. Photograph courtesy of *Serve*HAITI, 2006.

Figure # 14: Latrine at St. Pierre, Grand Bois, Haiti
Latrine at school in St. Pierre with no privacy. This is the closest site to the medical clinic and is a major population center in Grand Bois. Photo courtesy of *Serve*HAITI, 2006.

Leogane Study: The Leogane study took place in January 1996 in the small urban town of Leogane, Haiti, which is about 40 kilometers west of Port-au-Prince, the capital. This study looked at 996 students age five to 13 years at five primary schools. Schools were located within the city or in nearby suburban districts and were chosen on a convenience basis. All children in grades one through four at each school were enrolled, but eighteen students had missing stool studies and were dropped, bringing the total to 978 subjects for use as a comparison population to the Grand Bois Study group. Four of the five schools had latrines but none had running water for hand washing. The city itself has piped water, which is not improved in any way. Of possible import to transmission

of STHs, the soil is described as loamy and the air temperature rarely goes below 70^{o} F (personal communication P. Lammie, 1/2007). Education officials verified the absence of any deworming programs in the schools in the twelve months leading up to data collection (Beach et al., 1999).

This was a more extensive study than the Grand Bois study with many different variables considered. Pre- and post-treatment stool, urine, blood, and anthropometric data was obtained and students were excluded from the study if data was not complete. Only relevant comparable data were extracted from that set for comparison to the Grand Bois data set. Although identical variables were investigated, different methods were used. Weights were measured using a Seca 770 scale, which like the unit used in Grand Bois, is a digital bathroom-style scale. Heights were measured using a stadiometer (height board) and recorded to the nearest 0.1 cm. Hematocrit using a spun centrifuged sample was used to assess anemia. Because of limited personnel and the large number of subjects studied, time constraints made using the Kato-Katz method impossible. Instead all samples were collected and preserved for later study using a modified Stoll technique (Garcia & Bruckkner, 1997), which concentrates the stool via centrifuge. It requires more equipment and is not well suited to remote area use.

Method of Analysis:

Using SPSS v. 14.0 (SPSS Inc. Chicago, IL), the independent t-test was used to compare the Grand Bois and Leogane study site participants in terms of means of age, hemoglobin levels, and the three growth parameter Z-scores. This required cleaning the data, removing missing values, recoding variables, and merging data sets. Removing

missing values reduced the valid data by varying amounts depending on the variable studied. In Grand Bois, two subjects were dropped due to missing hemoglobin values, while valid data decreased from 226 to 140 participants for weight-for-height Z-scores because 86 students fell outside of the reference limits for this calculation. Reference limits were age up to 11.5 years and height less than 145cm for boys, and age up to 10 years and height less than 137 cm for girls (Dibley, Goldsby, Staehling, & Trowbridge, 1987; WHO Working Group, 1986). In the Leogane data set there were 89 missing values for hemoglobin out of 978 total students, and 19 missing for the weight-for-height Z-score variable.

The primary thesis analysis is of prevalence and intensity of STH infection. First, the prevalence and intensity of infection in Grand Bois was compared to that in Leogane and then to WHO standards in order to determine if mass deworming (community or school) is advisable and, if so, to what extent. Prevalence was simply determined by the presence or absence of intestinal helminth eggs in the stool regardless of intensity and was determined using microscopy with the Kato Katz technique. It was calculated by dividing the number of subjects with eggs in the stool by the total number of subjects in the study. This was done for *Ascaris*, *Trichuris*, and hookworms individually, or for Any STH, meaning the prevalence of at least one type of STH regardless of which type it may be. Intensity of infection was calculated by multiplying the number of eggs counted per slide by 24 to arrive at the number of eggs per gram of stool. Different commercial Kato-Katz kits may use different volumes of stool in slide preparation and thus must use different multipliers to arrive at an "eggs per gram" figure. The Leogane study used the modified Stoll concentration technique to assess presence and intensity of infection. This

required multiplying eggs per slide by 40 to arrive at eggs per gram of stool. This data conversion was essential for both inter-study comparison and for comparing data to WHO standards. Table 4 defines the categories based on presence and degree of infection.

Table 4: Categories of Intensity of Intestinal Infection[2]

	Eggs Per Gram of Stool		
	Ascaris	*Trichuris*	Hookworm
No Infection	0	0	0
Mild Infection	1—4999	1—999	1—1,999
Moderate Infection	5000—49,999	1000—9,999	2000—3,999
Heavy Infection	≥ 50,000	≥10,000	≥4,000

[2]Adapted from (Montresor et al., 2002)

Montresor, et al. (2002) suggest the following protocol to determine the frequency of deworming in a community (Table 5):

Table 5: Determining the Frequency of Treatment[5]			
	Prevalence and Intensity of Helminth Infections		
Deworming Treatment Frequency	High Prevalence &/or High Intensity	Moderate Prevalence & Low Intensity	Low Prevalence & Low Intensity
2-3 times per year	XXX		
Once yearly		XXX	
No Deworming, Treat only ill patients			XXX

High prevalence and/or high intensity is defined as prevalence of Any STH exceeding 70% of the sample, and/or percentage of moderately/heavily-infected individuals exceeding 10% of the sample. Moderate prevalence and low intensity is defined as prevalence of Any STH between 50 and 70%, and the percentage of moderately/heavily-infected individuals less than 10%. Low prevalence and low intensity is defined as prevalence of Any STH less than 50%, and percentage of moderately/heavily infected individuals less than 10% (Montresor et al., 2002). Thus, for purposes of determining frequency of treatment in a population-based prevention program, those with moderate infections and those with heavy infections are treated as if they are in one category and so will henceforth be referred to as “moderate/heavy” infections. For example, a patient with over 5000 *Ascaris* eggs-per-gram of stool falls into the moderate/heavy category.

Likewise, anyone with over 2000 hookworm eggs would fall into the moderate/heavy category as well (Table 4). From a deworming program perspective, it does not matter if the hookworm patient has 2000 eggs or 10,000. The algorithm is the same. For purposes of clinical treatment guidelines, however, this merging of two severity categories may not be approriate. An individual patient with heavy infection might well require more intensive treatment and monitoring than one with moderate infection. This is an individual-level decision by a healthcare provider based on the clinical situation. This difference speaks to the inherent dichotomy that sometimes exists between a public health measure and a clinical intervention. Lastly, the WHO protocols do not depend on which particular worms are most prevalent or causing the most intense infection when making a deworming decision. For this reason a new variable was created in SPSS called "Any STH" which allowed for prevalence and intensity calculations for patients with any of the three STHs looked at in this study.

When analysis is completed, specific deworming recommendations will be made in writing to the directors of *Serve*HAITI, to the medical director of the St. Vincent de Paul Medical Center in La Pointe, Grand Bois, Haiti, and to the Haitian Ministry of Health. If a difference is found between the two data sets in prevalence or intensity, potential explanations for those differences will be discussed.

Next, a series of four case-control studies was established, looking at two independent variables for infection and two potential outcomes of infection. Chi Square and Fisher Exact non-parametric tests were used to determine the significance of the relationship between age and STH infection, and gender and STH infection. The age study involved looking at children under ten years of age and comparing them to those

ten years and older. There were not enough children in the Grand Bois study to look at finer age gradations.

Using the same study design and statistical tests, the relationship between hookworm infection and prevalence of anemia in the samples was examined. Cases were those with anemia and controls were those without anemia. The independent variable was presence or absence of hookworm infection. There were no patients in either study with moderate/heavy hookworm infections so this could not be looked at as an independent variable. In the Grand Bois group anemia is defined as a hemoglobin ≤11 gm/dl, as this level is two standard deviations below the mean for US children and adolescents (Robertson & Shilkofski, 2005) and a level below which adverse health consequences are likely. In the Leogane group, anemia is defined as a hematocrit level ≤33%, as this is roughly equivalent to a hemoglobin of 11 gm/dl, and was the cutoff used by the CDC in the Leogane study. For reporting purposes hematocrits were converted to equivalent hemoglobin values by dividing hematocrit values by the number three. This makes comparisons between groups easier to follow.

The last set of analyses involved looking at *Ascaris* infections and Any STH infections as independent variables and three measures of growth as outcomes: Height-For-Age, Weight-for-Age, and Weight-For-Height. Heights, weights and ages for each subject in Grand Bois and Leogane were entered into the nutrition program of Epi Info 3.3.2 (CDC, Atlanta, GA), where the 1978 CDC/WHO growth reference curves (Dibley et al., 1987; WHO Working Group, 1986) were used to generate Z-scores for each growth parameter. This reference group was chosen instead of the updated 2000 CDC/WHO version for three reasons. First, it included data for a greater age, height, and

weight range, which was important given subjects in the Grand Bois study were up to 18years of age. Second, it is the recommended reference source for international studies (Dibley et al., 1987; WHO Working Group, 1986). Third, it is the reference source used in the Leogane study and therefore provides more valid comparisons between study groups.

The Z-score is a measure without units which represents the number of standard deviations above or below the mean for a particular value (Le, 2001; Wikipedia, 2007). A negative 1.0 is one standard deviation below the mean; a positive 0.5 is one half standard deviation above the mean; and a zero score is the mean. Arithmetically it is represented by the formula:

$$Z = (X-U)/\sigma$$

Where,

Z = Z-score

X = The Measure of Interest ("weight-for-age" for an individual, for example)

U = Population Mean

σ = Standard Deviation of the Population (Le, 2001)

Z-score data was imported to Microsoft Excel 11.3.3 and opened in SPSS v.14.0 where it was merged into the respective data sets for each study group. Z-scores were then recoded into quartiles for use in cross-tabulation. Those children in the highest quartile for each growth parameter were compared to those in the lowest quartile for prevalence and intensity of *Ascaris* and Any STH eggs.

Chapter IV: Results

Comparison of Study Site Participants:

As noted in Table 2 on page 26, the two study regions differ on a number of key factors including temperature, terrain, proximity of services, and general socio-economic status of the communities. In addition, the two study populations differ with respect to age range, average age, hemoglobin levels, and in each of three growth parameters as shown in Table 6 below. Of note, the Grand Bois sample was skewed towards female majority while gender was equally represented in Leogane. The children in Grand Bois were significantly older, had a wider age distribution, and higher hemoglobin counts as compared to their counterparts in Leogane. In addition, they were smaller with lower height-for-age and weight-for-age than children in Leogane. They were, however, more proportionate with weight-for-height being significantly closer to the reference mean than for those children in Leogane. Lastly, the per capita income in Grand Bois is only 40% of that in Leogane.

Table 6: Comparison of Grand Bois and Leogane Study Participants

	Grand Bois	Leogane	Independent T Test, Comparison of Means
Number of Subjects	226	978	
Race	Black	Black	
Gender	M 43.7% F 56.3%	M 51.5% F 48.5%	P-value = 0.032[7]
Age Range (yrs)	3–18	5–13	
Mean Age (yrs)	9.78	7.46	P-value < 0.001
Average Hemoglobin	12.7	12.4	P-value = 0.001
Average Height for Age Z-score	–0.9839	–0.4476	P-value < 0.001
Average Weight for Age Z-score	–0.8762	–0.5482	P-value < 0.001
Average Weight for Height Z-score	–0.110	–0.3665	P-value = 0.001
Average Per Capita Income (USD)[6]	262	650	* * *

[6] From (Ministere De L' Economie Et Des Finances, 2000a)
[7] Chi Square

Results of Analysis:

Table 7 shows the number of children in each school tested and the number and percent positive at any intensity level for each type of worm. The last column, “Any STH”, refers to whether any one of the three worm types was identified in a child. This column is important, as it indicates the overall prevalence rate of soil-transmitted helminths in the population, which will be used to determine the need for population-based deworming. The prevalence of Any STH is 50.9% in Grand Bois, ranging from 20.9% in school #4 (Courette) to 77.6% in school #3 (Palmes). Overall prevalence is 55.5% in Leogane, with a range of 40% to 70.5% depending on the school surveyed. *Ascaris* predominates in Grand Bois with 49.5% of children positive, while *Trichuris* is most common in Leogane with 43.4% of children infected. The greatest difference between the two communities is in prevalence of *Trichuris* infection (6.6% in Grand Bois and 43.4% in Leogane). There is low prevalence of hookworm infection in both communities with the exception of school #3 in Palmes, Grand Bois with 18.4% of stools revealing hookworm eggs. This is also the site of the highest overall STH prevalence with over 77% of children infected with at least one type of STH.

Table 7: Number Positive and Prevalence Rates for Individual STHs and Any STHs at Any Level of Intensity

Region	No. Tested	Number and Percent Positive For Any Intensity Infection			
		Ascaris	*Trichuris*	Hookworm	Any STH
Grand Bois:		Number (%)	Number (%)	Number (%)	Number (%)
School					
1	29	16 (55.2)	3 (10.3)	0 (0)	17 (58.6)
2	50	26 (52)	2 (4)	0 (0)	26 (52)
3	49	37 (75.5)	5 (10.2)	9 (18.4)	38 (77.6)
4	48	10 (20.9)	4 (8.3)	1 (2.1)	10 (20.9)
5	50	23 (44)	1 (2)	0 (0)	24 (48)
All Schools	**226**	**112 (49.5)**	**15 (6.6)**	**10 (4.4)**	**115 (50.9)**
Leogane:					
School					
1	118	34 (28.8)	52 (44.1)	2 (1.7)	66 (55.9)
2	206	87 (42.2)	101 (49)	15 (7.3)	135 (65.5)
3	200	77 (38.5)	119 (59.5)	38 (19)	141 (70.5)
4	246	56 (22.8)	92 (37.4)	11 (4.5)	118 (48)
5	208	42 (20.2)	60 (28.8)	5 (2.4)	83 (39.9)
All Schools	**978**	**296 (30.3)**	**424 (43.4)**	**71 (7.3)**	**543 (55.5)**

Table 8 shows the low number and percentage of children with moderate/heavy infection with any of these worms. In fact, no child in Grand Bois had moderate/heavy infection with either *Trichuris* or hookworm, while 20 children had such levels with *Ascaris*. In Leogane no child had moderate/heavy hookworm infection, and few reached this level with either *Ascaris* or *Trichuris* (15 and 12, respectively, out of 978 students). Of note, of any child with moderate/heavy infection with any species of STH, all such infections fell into the moderate range; no subjects in either data set had heavy infection as defined by the WHO. For example, the highest *Ascaris* egg count in either study group was 26,640 eggs per gram of stool in a child from Leogane, which falls well below the 50,000 count required for the highest level of infection per WHO criteria as noted in Table #4 (raw data not shown). In summary, Leogane has very low prevalence rates of high intensity infection for any of the three worms (*Ascaris* 1.5%, *Trichuris* 1.2%, hookworm 0%). The peak value was for Any STH was in school #1 at 8.5%. In Grand Bois, although only 8.8% of children had moderate/high intensity infection (all due to *Ascaris*), school #1 at Mathurin had over 20%, and school #3 at Palmes had over 14%.

Tables 7 and 8 also reveal that in Grand Bois there is a statistically significant difference in prevalence and intensity of infection between the schools, with Mathurin and Palmes reporting more infection with *Ascaris* and Any STH and the schools in St. Pierre and Courette reporting less (Chi Square 36.49, P-value = 0.000). The prevalence of *Trichuris* and hookworm was not high enough to make an inter-school comparison. Similarly, in Leogane significant differences exist between the schools with Chi Square values ranging from 56 to 82 and P-values equaling zero for the four worm categories. No further information is available on the names, sanitary facilities available, or socio-

economic status (SES) of the children attending particular Leogane schools so discussing potential reasons for school differences is not possible within the scope of this manuscript.

Table 8: Number Positive and Prevalence Rates for Individual STHs and Any STHs at Moderate/Heavy Levels of Infection

Region	# Tested	Number and Percent Positive for Moderate/Heavy Intensity Infection			
		Ascaris	*Trichuris*	Hookworm	Any STH
Grand Bois:		Number (%)	Number (%)	Number (%)	Number (%)
School					
1	29	6 (20.7)	0 (0)	0 (0)	6 (20.7)
2	50	3 (6)	0 (0)	0 (0)	3 (6)
3	49	7 (14.3)	0 (0)	0 (0)	7 (14.3)
4	48	2 (4.2)	0 (0)	0 (0)	2 (4.2)
5	50	2 (4)	0 (0)	0 (0)	2 (4)
All Schools	**226**	**20 (8.8)**	**0 (0)**	**0 (0)**	**20 (8.8)**
Leogane:					
School					
1	118	7 (5.9)	3 (2.5)	0 (0)	10 (8.5)
2	206	5 (2.4)	7 (3.4)	0 (0)	10 (4.9)
3	200	1 (0.5)	2 (1)	0 (0)	2 (1.0)
4	246	1 (0.4)	0 (0)	0 (0)	1 (0.4)
5	208	1 (0.5)	0 (0)	0 (0)	1 (0.5)
All Schools	**978**	**15 (1.5)**	**12 (1.2)**	**0 (0)**	**24 (2.4)**

Tables 9 through 13 summarize the differences between the two study sites in prevalence and intensity of infection with each worm type and with Any STH. Table 9 compares the two communities for each of three intensity levels: no infection, low infection, and moderate/high infection. Results show statistical differences between the communities for *Ascaris*, *Trichuris*, and Any STH, while no analysis could be completed for hookworm infection, as two of the cells had values of zero. The next four tables compare the odds of having “any intensity of infection” and “moderate/heavy” infection to “no infection” with the three worm types and Any STH. For each of these determinations the reference value is assigned to Leogane. The odds of *Ascaris* infection are 2.26 times greater in Grand Bois than Leogane, and the odds of heavy infection are almost eight times as high in Grand Bois (Table 10). For *Trichuris* infection the reverse is true, with the odds for those living in Grand Bois significantly less than for those in Leogane (OR = 0.09, 95% CI 0.05, 0.16). For moderate/severe infections no odds ratio was calculable, as no one in Grand Bois had infection at this intensity (Table 11). Fisher Exact test reveals significant differences do exist with a two-tailed P-value = 0.043.

Table 12 reveals no significant difference between prevalence of hookworm between the two communities (OR 0.59, 95% CI 0.28, 1.21). There were no cases of moderate/heavy infection in either community and therefore no analysis was possible for this severity class. Table 13 indicates no significant difference in prevalence of Any STH at “any intensity” between the two communities, but Grand Bois did have significantly higher odds of moderate/heavy infections (OR 3.27, 95% CI 1.66, 6.40). In Grand Bois the Any STH category was dominated by *Ascaris* infection, while in Leogane it was dominated by *Trichuris* infection.

Table 9: Comparison of all Infections, all Intensities, Both Sites

	Ascaris Infection: Intensity Level				
	None	Low	Moderate/High	Chi Square	P-value
	No. (%)	No. (%)	No. (%)		
Grand Bois*	114 (50.4)	92 (40.7)	20 (8.8)	52.63	<0.001
Leogane**	682 (69.7)	281 (28.7)	15 (1.5)		

	Trichuris Infection: Intensity Level				
	None	Low	Moderate/High	Chi Square	P-value
	No. (%)	No. (%)	No. (%)		
Grand Bois	211 (93.4)	15 (6.6)	0 (0)	106.92	<0.001
Leogane	554 (56.6)	412 (42.1)	12 (1.2)		

	Hookworm Infection: Intensity Level				
	None	Low	Moderate/High	Chi Square	P-value
	No. (%)	No. (%)	No. (%)		
Grand Bois	216 (95.6)	10 (4.4)	0 (0)	***	***
Leogane	907 (92.7)	71 (7.3)	0 (0)		

	Any STH Infection: Intensity Level				
	None	Low	Moderate/High	Chi Square	P-value
	No. (%)	No. (%)	No. (%)		
Grand Bois	111 (49.1)	95 (42)	20 (8.8)	25.8	<0.001
Leogane	435 (44.5)	519 (53.1)	24 (2.5)		

* N = 226   ** N = 978   *** Not calculable with column adding up to zero

Table 10: Comparison of *Ascaris* Infection Between Study Sites

	Any Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval
Grand Bois	112 (49.5)	114 (50.5)	2.26	(1.67, 3.07)
Leogane	296 (30.3)	682 (69.7)	Ref	

	Moderate/Heavy Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval
Grand Bois	20 (8.8)	114 (50.5)	7.98	(3.77, 16.95)
Leogane	15 (1.5)	682 (69.7)	Ref	

Table 11: Comparison of *Trichuris* Infection Between Study Sites

	Any Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval
Grand Bois	15 (6.6)	211 (93.4)	0.09	(0.05,0.16)
Leogane	424 (43.4)	554 (56.6)	Ref	

	Moderate/Heavy Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval
Grand Bois	0 (0)	211 (93.4)	***	*
Leogane	12 (1.2)	554 (56.6)	Ref	

* No CI calculable, Fisher Exact Test P-value = 0.043 (done for values of < 5)
*** Not Calculable with value of zero in a cell

Table 12: Comparison of Hookworm Infection Between Study Sites

	Any Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval
Grand Bois	10 (4.4)	216 (95.6)	0.59	(0.28, 1.21)
Leogane	71 (7.3)	907 (92.7)	Ref	

	Moderate/Heavy Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval
Grand Bois	0 (0)	216 (95.6)	***	***
Leogane	0 (0)	907 (92.7)	Ref	

*** Not calculable with zeros in > one cell

Table 13: Comparison of Any STH Infection Between Study Sites

	Any Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval
Grand Bois	115 (50.9)	111 (49.1)	0.83	(0.61, 1.12)
Leogane	543 (55.5)	435 (44.5)	Ref	

	Moderate/Heavy Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval
Grand Bois	20 (8.8)	111 (49.1)	3.27	(1.66, 6.40)
Leogane	24 (2.5)	435 (44.5)	Ref	

Next, Tables 14a through 15b look at the relationship between age and STH infections for each site and for all intensities. Children were divided into a younger group (<10 years) and an older group (≥10 years) and chi square analyses were performed. When fewer than five subjects occupied a cell, the Fisher Exact test was performed. If two cells had no subjects then no analysis was possible, as was the case for moderate/heavy infection with *Trichuris* and hookworm in Grand Bois, and hookworm in Leogane. Tables 14a and 14b show that younger children in Grand Bois have higher odds of moderate/heavy infection with *Ascaris* than do older children (OR 7.25, 95% CI 2.29. 24.35). Similar results were noted for Any STH, as this group is dominated by, and parallels the findings of, the *Ascaris* group (4.09, 95% CI 1.27, 19.9). Borderline significant differences were also noted for hookworm infection with younger children having increased odds (OR 4.91, 95% CI 0.93, 34.29). No significant differences between age groups were noted for "any intensity" of infection with *Ascaris*, *Trichuris*, or Any STH groups.

Tables 15a and 15b provide similar age related analyses for Leogane. The opposite relationship was found here, with hookworm infection being significantly less common in younger children (OR 0.48, 95% CI 0.24, 0.99). No other age related differences were noted for any other STHs at any level of intensity.

Table 14a: Age and STH Infection in Grand Bois

	Ascaris					
	Any Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
< 10 years	57 (54.3)	48 (45.7)	1.42	(0.82, 2.49)	1.75	0.1854
≥ 10 years	55 (45.5)	66 (54.5)	Ref			
	Moderate/Heavy Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
< 10 years	15 (14.3)	48 (45.7)	7.25#	(2.29, 24.35)#	16.56	<0.001
≥ 10 years	5 (4.1)	66 (54.5)	Ref			

	Trichuris					
	Any Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
< 10 years	8 (7.6)	97 (92.4)	1.34	(0.42, 4.30)	0.31	0.5806
≥ 10 years	7 (5.8)	114 (94.2)	Ref			
	Moderate/Heavy Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
< 10 years	0 (0)	97 (92.4)	***	***	***	***
≥ 10 years	0 (0)	114 (94.2)	Ref			

Significant value *** No statistics possible with zeros in 2 cells

Table 14b: Age and STH Infection in Grand Bois

	Hookworm					
	Any Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
< 10 years	8 (7.6)	97 (92.4)	4.91	(0.93, 34.29)	***	0.0476**
≥ 10 years	2 (1.7)	119 (98.3)	Ref			
	Moderate/Heavy Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
< 10 years	0 (0)	97 (92.4)	****	****	****	****
≥ 10 years	0 (0)	119 (98.3)	Ref			

	Any STH					
	Any Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
< 10 years	58 (55.2)	47 (44.8)	1.39	(0.79, 2.42)	1.49	0.223
≥ 10 years	57 (47.1)	64 (52.9)	Ref			
	Moderate/Heavy Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
< 10 years	15 (14.3)	47 (44.8)	4.09[#]	(1.27, 19.9)	7.25	0.007
≥ 10 years	5 (4.1)	64 (52.9)	Ref			

*** <5 in one cell ** Fisher Exact test **** No stats with zeros in >one cell # Significant value

Table 15a: Age and STH Infection in Leogane

Ascaris

	Any Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
< 10 years	272 (30.7)	613 (69.3)	1.28	(0.77, 2.14)	0.97	0.3251
≥ 10 years	24 (25.8)	69 (74.2)	Ref			
	Moderate/Heavy Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
< 10 years	12 (1.4)	613 (69.3)	0.45	(0.11, 2.06)	***	0.1953*
≥ 10 years	3 (3.2)	69 (74.2)	Ref			

Trichuris

	Any Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
< 10 years	381 (43.1)	504 (56.9)	0.88	(0.56, 1.38)	0.35	0.5554
≥ 10 years	43 (46.2)	50 (53.8)	Ref			
	Moderate/Heavy Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
< 10 years	9 (1.0)	504 (56.9)	0.3	(0.07. 1.44)	***	0.0931*
≥ 10 years	3 (3.2)	50 (53.8)	Ref			

*** No chi square possible, <5 in a cell

* Fisher Exact Test

Table 15b: Age and STH Infection in Leogane

	Hookworm					
	Any Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
< 10 years	59 (6.7)	826 (93.3)	0.48	(0.24, 0.99)#	4.86	0.0275
≥ 10 years	12 (12.9)	81 (87.1)	Ref			
	Moderate/Heavy Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
< 10 years	0 (0)	826 (93.3)	****	****	****	****
≥ 10 years	0 (0)	81 (87.1)	Ref			

	Any STH					
	Any Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
< 10 years	491 (55.5)	394 (44.5)	0.99	(0.63, 1.55)	0	0.9641
≥ 10 years	52 (55.9)	41 (44.1)	Ref			
	Moderate/Heavy Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
< 10 years	20 (2.3)	394 (44.5)	0.52	(0.16, 1.90)	***	0.2784*
≥ 10 years	4 (3.6)	41 (44.1)	Ref			

*** No chi square, value <5 * Fisher Exact Test **** No stats possible with zeros in > one cell # significant value

In Tables 16a through 17b prevalence and intensity of the four categories of STH infections are compared for boys and girls. Once again, there were no moderate/heavy infections for *Trichuris* or hookworm in Grand Bois, and none for hookworm in Leogane. Analyses of other STHs revealed no statistical differences between the genders for any category or any severity of STH infection. Overall, in both locations, boys have higher odds of STH infections than do girls (OR range from 1.1 to 1.5) but these did not reach significance. The one exception was for hookworm infection in Grand Bois, where boys were only half as likely to be infected as girls (OR 0.55) but this also did not reach significance (P-value 0.3831).

Table 16a: Gender and STH Infection in Grand Bois

Ascaris

	Any Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
Boy	53 (54.1)	45 (45.9)	1.39	(0.79, 2.42)	1.42	0.2339
Girl	59 (46.1)	69 (53.9)	Ref			

	Moderate/Heavy Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
Boy	10 (10.2)	45 (45.9)	1.53	(0.54, 4.39)	0.78	0.3774
Girl	10 (10.2)	69 (53.9)	Ref			

Trichuris

	Any Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
Boy	8 (8.2)	90 (91.8)	1.54	(0.48, 4.92)	0.65	0.4199
Girl	7 (5.5)	121 (94.5)	Ref			

	Moderate/Heavy Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
Boy	0 (0)	90 (91.8)	***	***	***	***
Girl	0 (0)	121 (94.5)	Ref			

*** Zeros in >1 cell, no stats

Table 16b: Gender and STH Infection in Grand Bois

Hookworm

	Any Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
Boy	3 (3.1)	95 (96.9)	0.55	(0.11, 2.43)	0.76	0.3831
Girl	7 (5.5)	121 (94.5)	Ref			

	Moderate/Heavy Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
Boy	0 (0)	95 (96.9)	***	***	***	***
Girl	0 (0)	121 (94.5)	Ref			

Any STH

	Any Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
Boy	54 (55.1)	44 (44.9)	1.35	(0.77, 2,37)	1.23	0.2672
Girl	61 (47.6)	67 (52.3)	Ref			

	Moderate/Heavy Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
Boy	10 (10.2)	44 (44.9)	1.52	(0.53, 4.37)	0.75	0.3862
Girl	10 (7.8)	67 (52.3)	Ref			

*** Zeros in more than one cell, no statistics possible

Table 17a: Gender and STH Infection in Leogane

Ascaris

	Any Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
Boy	156 (30.9)	348 (69.1)	1.07	(0.81, 1.42)	0.23	0.6299
Girl	140 (29.5)	334 (70.5)	Ref			

	Moderate/Heavy Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
Boy	8 (1.6)	348 (69.1)	1.1	(0.36, 3.40)	0.03	0.8597
Girl	7 (1.5)	334 (70.5)	Ref			

Trichuris

	Any Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
Boy	218 (43.3)	286 (56.7)	0.99	(0.76, 1.29)	0	0.9482
Girl	206 (43.5)	268 (56.5)	Ref			

	Moderate/Heavy Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
Boy	7 (1.4)	286 (56.7)	1.31	(0.37, 4.82)	0.21	0.6454
Girl	5 (1.1)	268 (56.5)	Ref			

Table 17b: Gender and STH Infection in Leogane

	Hookworm					
	Any Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
Boy	39 (7.7)	465 (92.3)	1.16	(0.69, 1.93)	0.35	0.5522
Girl	32 (6.8)	442 (93.2)	Ref			
	Moderate/Heavy Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
Boy	0 (0)	465 (92.3)	***	***	***	***
Girl	0 (0)	442 (93.2)	Ref			

	Any STH					
	Any Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
Boy	281 (55.8)	223 (44.2)	1.02	(0.79, 1.32)	0.02	0.8801
Girl	262 (55.3)	212 (44.7)	Ref			
	Moderate/Heavy Intensity Number (%)	No Infection Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
Boy	13 (2.6)	223 (44.2)	1.12	(0.46, 2.76)	0.08	0.7818
Girl	11 (2.3)	212 (44.7)	Ref			

*** No stats, zeros in >1 cell

Table 18 shows no increased prevalence of anemia with hookworm infection for either study group. Of note, since there were no moderate/heavy hookworm infections in any child at either site, "Any Intensity" for hookworm represents only mild infection. In Grand Bois there were no children with concurrent anemia and hookworm infection making odds ratios impossible to calculate. Only small numbers of children had either hookworm infection or anemia at either study site. In Leogane the odds were almost equal for being anemic with and without hookworm infection (OR 1.02, P-value 0.9564).

Table 18: Anemia and Hookworm Infection

Severity of Infection	Anemia (Hgb ≤ 11) Number (%)	No Anemia (Hgb > 11) Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
Grand Bois (n = 224)						
Any Intensity	0 (0)	10 (100)	**	**	***	0.6055***
No Infection	20 (9.3)	194 (90.7)	Ref			
Leogane (n = 889)						
Any Intensity	6 (8.9)	61 (91.1)	1.02	(0.38, 2.57)	0	0.9564
No Infection	72 (8.8)	750 (91.2)	Ref			

** Zero in one cell, no OR possible

*** Value < 5 in one cell Fisher Exact Test

This next section looks at the relationship between STH infections and anthropometric data. Table 19 shows a summary of the Z-score data for the two sites, including means, standard deviations, and quartile values. The children in Grand Bois are smaller than those in Leogane for both height-for-age and weight-for-age parameters. They are, however, more proportionate in their growth with weight-for-height Z-scores closer to the mean 1978 reference values published by CDC/WHO. Tables 20 through 22 refer to Grand Bois, and tables 23 through 25 to Leogane. *Ascaris* was chosen as the primary independent variable of interest because of its well-described affect on growth parameters as noted in other studies. "Any STH" was added to try to capture the effect of other STH species. For both of these independent variables there was enough data for analysis to have adequate power. The other major STH known to affect growth is *Trichuris trichiura* but there were only a few infections with this organism in Grand Bois, making analysis less robust. Children with no infection serve as the reference value and those in the highest quartile were compared to those in the lowest quartile for each parameter.

No significant association was found in Grand Bois between infection with *Ascaris* or Any STH and growth failure. In fact, no consistent trends were found. Children with moderate/heavy infection were less likely to fall in the lowest quartile for height-for-age and weight-for-age as compared to those without infection (OR 0.50 range). On the other hand, for "any intensity" of infections the reverse was true with odds ratios between 1.4 and 1.5 for those with infection being smaller than those without. None of these values reached statistical significance. Similarly, no relationship exists

between weight-for-height and STH as noted in Table 22. In Leogane, exactly the same trends were seen with those more highly infected less likely to be in the lowest quartile for height-for-age and weight-for-age (OR between 0.22 and 0.62) but these did not reach significance either. For those with "any intensity" of infections the odds were slightly higher (1.06 to 1.32) that they fell into the smallest quartiles but this too was not significant. Lastly, in Table 25, no relationship existed between those with any level of infection and the weight-for-height growth parameter with odds ratios approaching 1.0. When *Trichuris* was looked at independently in Grand Bois, the odds were greater for those infected to fall in the lowest quartile of growth parameters (OR 3.13 and 2.17 for height-for-age, and weight-for-age respectively) but due to low absolute numbers, statistical significance was not reached[1].

[1] 95% CI (0.53, 23.67; 0.32, 17.96) and Fisher Exact Test Two-Tailed P-values 0.2706 and 0.4328, respectively. Total number of *Trichuris* infections in Grand Bois = 15.

Table 19: Means, Standard Deviations, Quartiles for Anthropometric Z-Scores

	Height-For-Age		Weight-For-Age		Weight-For-Height	
	Grand Bois	Leogoane	Grand Bois	Leogoane	Grand Bois	Leogoane
Valid #	223	978	223	978	140	959
Mean	-0.9839	-0.44	-0.8762	-0.54	-0.11	-0.36
Standard Deviation	1.23	1.14	0.87	0.99	0.95	0.79
25th %	-1.8	-1.23	-1.52	-1.22	-0.52	-0.88
50th %	-0.96	-0.43	-0.89	-0.63	-0.12	-0.42
75th %	-0.33	0.33	-0.29	0.11	0.415	0.13

Table 20: Anthropometrics (Height-For-Age Z scores) and STHs in Grand Bois

Intensity (number)**	Height-For-Age Lowest Quartile Number (%)	Height-For-Age Highest Quartile Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
Ascaris						
Any Infection (107)	25 (23.4)	20 (18.7)	1.38	(0.59, 3.22)	0.67	0.4146
No Infection (113)	29 (25.7)	32 (28.3)	Ref			
Ascaris						
Moderate/Heavy Infection (20)	2 (10)	4 (20)	0.55	(0.06, 3.92)	***	0.6784*
No Infection (113)	29 (25.7)	32 (28.3)	Ref			
Any STH						
Any Infection (109)	26 (23.9)	20 (18.3)	1.49	(0.64, 3.47)	1.01	0.3155
No Infection (111)	28 (25.2)	32 (28.8)	Ref			
Any STH						
Moderate/Heavy Infection (20)	2 (10)	4 (20)	0.57	(0.07, 4.07)	***	0.8451*
No Infection (111)	28 (25.2)	32 (28.8)	Ref			

*** Less than 5 in a cell, * Fisher Exact test, ** total number of infections in all four quartiles of Height-For-Age Z-scores

Table 21: Anthropometrics (Weight-For-Age Z scores) and STHs in Grand Bois

Intensity (number)**	Weight-For-Age Lowest Quartile Number (%)	Weight-For-Age Highest Quartile Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
Ascaris						
Any Infection (107)	25 (23.4)	20 (18.7)	1.47	(0.63, 3.4)	0.95	0.3291
No Infection (113)	29 (25.7)	34 (30.1)	Ref			
Ascaris						
Moderate/Heavy Infection (20)	2 (10)	4 (20)	0.59	(0.07, 4.15)	***	0.8665*
No Infection (113)	29 (25.7)	34 (30.1)	Ref			
Any STH						
Any Infection (109)	26 (23.8)	21 (19.3)	1.46	(0.63, 3.37)	0.94	0.3318
No Infection (111)	28 (25.2)	33 (29.7)	Ref			
Any STH						
Moderate/Heavy Infection (20)	2 (10)	4 (20)	0.59	(0.07, 4.19)	***	0.6838
No Infection (111)	28 (25.2)	33 (29.7)	Ref			

***Less than 5 in a cell, * Fisher Exact Test

** Total number of infections in all four quartiles of Weight-For-Age Z-scores

Table 22: Anthropometrics (Weight-For-Height Z scores) and STHs in Grand Bois

Intensity (number)**	Weight-For-Height Lowest Quartile Number (%)	Weight-For-Height Highest Quartile Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
Ascaris						
Any Infection (73)	20 (27.4)	18 (24.7)	1.37	(0.46, 4.05)	0.4	0.5267
No Infection (64)	13 (20.3)	16 (25)	Ref			
Ascaris						
Moderate/Heavy Infection (17)	6 (35.3)	4 (23.5)	1.85	(0.35, 10.16)	***	0.4801*
No Infection (64)	13 (20.3)	16 (25)	Ref			
Any STH						
Any Infection (74)	20 (27)	18 (24.3)	1.37	(0.46, 4.05)	0.4	0.5267
No Infection (63)	13 (20.6)	16 (25.4)	Ref			
Any STH						
Moderate/Heavy Infection (17)	6 (35.3)	4 (23.5)	1.85	(0.35, 10.16)	***	0.4801*
No Infection (63)	13 (20.6)	16 (25.4)	Ref			

*** <Five in a cell

* Fisher Exact Test

** Total number of infections in all four quartiles of Weight-For-Height Z-scores

Table 23: Anthropometrics (Height-For-Age Z scores) and STHs in Leogane

Intensity (number)**	Height-For-Age Lowest Quartile Number (%)	Height-For-Age Highest Quartile Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
Ascaris						
Any Infection (296)	88 (29.7)	101 (34.1)	1.17	(0.81, 1.70)	0.8	0.3703
No Infection (682)	158 (23.2)	213 (31.2)	Ref			
Ascaris						
Moderate/Heavy Infection (15)	1 (6.7)	6 (37.5)	0.22	(0.01, 1.90)	***	0.2464*
No Infection (682)	158 (23.2)	213 (31.2)	Ref			
Any STH						
Any Infection (544)	148 (27.2)	171 (31.4)	1.26	(0.89, 1.80)	1.83	0.1761
No Infection (435)	98 (22.5)	143 (32.9)	Ref			
Any STH						
Moderate/Heavy Infection (24)	3 (12.5)	9 (37.5)	0.49	(0.10, 2.02)	***	0.3721*
No Infection (435)	98 (22.5)	143 (32.9)	Ref			

*** < 5 in a cell, * Fisher Exact Test

** Total number of infections in all four quartiles of Height-For-Age Z-scores

Table 24: Anthropometrics (Weight-For-Age Z scores) and STHs in Leogane

Intensity (number)**	Weight-For-Age Lowest Quartile Number (%)	Weight-For-Age Highest Quartile Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
Ascaris						
Any Infection (296)	78 (26.4)	72 (24.3)	1.06	(0.71, 1.58)	0.08	0.7755
No Infection (682)	169 (24.8)	169 (24.8)	Ref			
Ascaris						
Moderate/Heavy Infection (15)	3 (20)	6 (40)	0.49	(0.10, 2.24)	***	0.3365*
No Infection (682)	169 (24.8)	169 (24.8)	Ref			
Any STH						
Any Infection (544)	144 (26.5)	122 (22.4)	1.32	(0.91, 1.92)	0.227	0.1315
No Infection (435)	103 (23.7)	115 (26.4)	Ref			
Any STH						
Moderate/Heavy Infection (24)	5 (20.8)	9 (37.5)	0.62	(0.17, 2.11)	0.7	0.4017
No Infection (435)	103 (23.7)	115 (26.4)	Ref			

*** < 5 in a cell, * Fisher Exact Test

** Total number of infections in all four quartiles of Weight-For-Age Z-scores

Table 25: Anthropometrics (Weight-For-Height Z scores) and STHs in Leogane

Intensity (number)**	Weight-For-Height Lowest Quartile Number (%)	Weight-For-Height Highest Quartile Number (%)	Odds Ratio	95% Confidence Interval	Chi Square	P-value
Ascaris						
Any Infection (287)	61 (21.3)	66 (22.9)	0.86	(0.56, 1.31)	0.54	0.4614
No Infection (672)	183 (27.2)	170 (25.3)	Ref			
Ascaris						
Moderate/Heavy Infection (14)	3 (21.4)	3 (21.4)	0.93	(0.15, 5.84)	***	1.000*
No Infection (672)	183 (27.2)	170 (25.3)	Ref			
Any STH						
Any Infection (530)	131 (24.7)	127 (23.9)	0.99	(0.68, 1.45)	0	0.9781
No Infection (429)	113 (26.3)	109 (25.4)	Ref			
Any STH						
Moderate/Heavy Infection (22)	4 (18.2)	4 (18.2)	0.96	(0.2, 4.72)	***	1.000*
No Infection (429)	113 (26.3)	109 (25.4)	Ref			

*** Cell <5, * Fisher Exact Test

** Total number of infections in all four quartiles of Weight-For-Height Z-scores

Summary of Data as Related to the Hypotheses:

Hypothesis #1: The data leads to rejection of the null hypothesis and acceptance of the alternate hypothesis. The prevalence of Any STH is greater than 50% in Grand Bois.

Hypothesis #2: The data leads to acceptance of the null hypothesis. The prevalence of heavy infection with Any STH is less than 10% in Grand Bois.

Hypothesis #3: The data leads to acceptance of the null hypothesis. The prevalence of STH in Grand Bois is equally common in older and younger age groups. Heavier infections are more common in the younger children, however.

Hypothesis #4: The data leads to acceptance of the null hypothesis. Boys and girls are equally likely to be infected in Grand Bois with STH.

Hypothesis #5: The data leads to acceptance of the null hypothesis. Anemia is not more common in children in Grand Bois with hookworm infection.

Hypothesis #6: The data leads to acceptance of the null hypothesis. Height-For-Age is not decreased in children in Grand Bois with *Ascaris* or Any STH infection.

Hypothesis #7: The data leads to acceptance of the null hypothesis. Weight-For-Age is not decreased in children in Grand Bois with *Ascaris* or Any STH infection.

Hypothesis #8: The data leads to acceptance of the null hypothesis. Weight-For-Height is not decreased in children in Grand Bois with *Ascaris* or Any STH infection.

Chapter V: Discussion

Interpretation of Results:

Limited medical and public health resources in both developed and developing nations mandate the use of evidence-based interventions to maximize utility of those resources. This is of paramount importance in the poorest nations of the world as implementing an unneeded program takes healthcare dollars from other potentially life saving or life improving interventions. Haiti is one such nation, suffering from low economic status, high prevalence of many diseases, and a paucity of clinically based medical and public health research. This study adds to the small amount of information published on the topic of soil-transmitted helminths in Haiti over the past decade.

Prevalence and Intensity within Grand Bois: The primary question was whether or not the remote region of Grand Bois had a high enough prevalence and severity of soil-transmitted helminths to warrant mass deworming. To determine this, prevalence rates of *Ascaris*, *Trichuris*, and hookworms in children were looked at separately and then in combination to determine presence of at least any one type of geo-helminth (labeled "Any STH"). As shown in Table 7, results revealed that 50.9% of children studied were positive for intestinal worms, with the majority of these being *Ascaris* (49.5%). In addition, the prevalence of moderate/severe worm infections in the sample was 8.8% across the region (Table 8), which is close to the 10% limit for labeling Grand Bois a "High Intensity" area for helminthiases. In fact, the confidence intervals for

the prevalence and intensity are as follows: 50.9% (95% CI 44.4%, 57.4%) for any severity of infection, and 8.8% (95% CI 5.1%, 12.5%) for higher severity infections. Thus, the true prevalence of more severe infections in the population could be greater than the 10% WHO delineation for a “High Prevalence &/or High Intensity” area (Table 5). If the true population rates are higher than 10% Grand Bois would be eligible for twice yearly dewoming per WHO guidelines. The sample results, however, support the implementation of a school-based deworming program for the Grand Bois region as follows: with prevalence between 50% and 70%, and moderate/severe infections at just under 10%, Grand Bois is considered a “Moderate Prevalence/Low Intensity” region (Table 5) and is best suited to once yearly deworming of all school children with either albendazole 400 mg or mebendazole 500mg. These come in convenient chewable tablets and each student receives the same dose regardless of age or weight. The program is easy to understand for teachers and lay healthcare workers, and is cost effective. See appendices D through G for examples of WHO forms that were used in the Grand Bois study and which could be used in a larger deworming program.

Two further considerations bear comment. First, of all infections in the moderate/heavy category, none of these were severe enough to be considered “heavy”. In essence, for both Grand Bois and Leogane this category could have better been defined at merely “moderate severity”. This lessens the temptation to consider Grand Bois a “high intensity” transmission community, even though the upper confidence limit was over 10%. Thus, the easier, safer, and more cost-effective choice is to limit deworming to a once yearly program. Second, prevalence of STH worms in school children is a reflection of the prevalence in the community at large. Another choice is to institute a

community-wide deworming program where every eligible resident (over one year of age, non-pregnant, for example) receives yearly treatment as was done by Boia in the Amazon and by Beach et al. in Leogane (1999; 2006). This would likely provide the advantage of decreasing overall community-wide prevalence to a greater extent, and thus decreasing deposition of STH eggs in the soil to a greater extent than with school-based deworming alone. The advantage with this approach is in improving primary prevention by reducing re-infection with STH in both children and adults. This would require more resources and might be feasible at this time in Grand Bois only with strong input by the Haitian MOH.

As noted in the results section in chapter 4 there were significant differences in prevalence and intensity of STH infections between the five schools in Grand Bois. No definitive reasons can be given for these differences based on study results, but new hypotheses can be generated based on observations by the field research team. Of note, the two higher-prevalence schools at Mathurin and Les Palmes were the two highest-elevation locations with the least convenient and dependable water sources. In addition, these two schools did not have latrines available for student use whereas the three lower prevalence schools did have latrines, albeit crude ones (Table 3). No data was available to this researcher on SES, housing facilities, home latrine availability, or any other potential variables. Looking closer at the individual communities may shed light on reasons for these differences and suggest possible interventions to mitigate the problems noted.

Prevalence and Intensity Between Grand Bois and Leogane: For the Leogane study group the overall rates of infection were similar with 55.5% of children infected

with Any STH, but they had significantly less *Ascaris* and significantly more *Trichuris* than did children in Grand Bois. They also had fewer children with more intense infections (2.4% versus 8.8%, P-value <0.001). Neither group had high rates of hookworm infection. Again, definitive reasons for the differences are not possible to ascertain from the data sets but several possibilities exist. First, the two sites differ in geography and climate. Grand Bois is much cooler in the winter, which inhibits the survival of *Trichuris* eggs and hookworm larvae in the soil. Leogane is warmer and has more constant humidity levels being a coastal town, factors that may aid survival of the more fragile species. Grand Bois is also much more remote with less sanitary infrastructure. Many more children likely defecate outside in the fields around the schools, as two of the five schools did not have latrines. In fact, a 2002 unpublished survey of the Grand Bois area revealed that 8% of residents had no access to latrines and used the fields around their homes for this purpose (*Serve*HAITI, 2002). The exposure to helminths is likely larger there than in the urban environs of Leogane and this may result in higher prevalences and higher intensity infections for certain species of STH. As noted in the literature review, this is consistent with what Boia and his team found in the Amazon, namely, more STH infections in those without family latrines (2006). Analysis of Leogane's prevalence and intensity rates reveal that it qualifies for once yearly deworming, as is currently being done. Leogane does not approach the need to consider twice yearly deworming per WHO guidelines as prevalence rates and intensity of disease do not put them close to the high prevalence/high intensity category.

The Leogane study was done in January 1996 and the Grand Bois study in March 2006. The cooler winter months, especially in the mountains, could be the low season for

acquiring *Trichuris* and hookworm infections as soil conditions are not optimal for survival of eggs and larva, so results, especially in Grand Bois, could be an underestimate of prevalence at other times during the year. No literature was found looking at this issue in Haiti, or in the rest of the Caribbean region. In addition, December to March is also the dry season and this creates a harsher environment for STHs. They prefer warmth and moistness, and not cold and dryness. Again, this supports, at the very least, instituting yearly deworming based on the numbers generated, and on the fact that prevalence may have been underestimated. Of note, *Ascaris* is the hardiest of the worm types and can withstand the harshest conditions outside the human body. Weather is therefore unlikely to play a large role in the intensity differences with this organism between the two sites given that the harsher environment of Grand Bois is where the highest prevalence of moderate/severe infections with *Ascaris* was seen. Human behavior related to poor sanitation infrastructure is the more likely answer.

Lastly, another consideration is the large disparity between *Trichuris* prevalence in Grand Bois and Leogane could have nothing to do with environmental conditions or sanitary practice. It could involve the level of laboratory expertise using the Kato-Katz technique. This technique takes practice; inexperienced examiners could undercount eggs on slides and thus the study could be methodologically flawed. Of note however, is that Champetier in his 2002 national survey, arrived at almost the identical *Trichuris* prevalence figures as were obtained in the Grand Bois study (7.3% national, versus 6.6% Grand Bois, see Table 26 on page 95). Leogane is the actual outlier with 43.4% prevalence for this STH, which leads one back to environmental differences as likely

being a large factor in this difference. This environmental explanation is supported in the literature as noted by Bundy in his STH study in St Lucia (1987).

Independent Variables and Outcomes:

Age: Consistent with theories on exposure and development of immunity, young school-aged children in Grand Bois did have more intense *Ascaris* infection than did older children (OR 7.25, 95% CI 2.29, 24.35). The literature supports this as well, with younger children more susceptible to heavy burdens as noted by Savioli (2004) and discussed previously in this manuscript. Interestingly when all intensities of infection were considered there was no difference in prevalence by age group. In the Leogane study group no differences were noted between age groups at any level of intensity although age range in that data set was narrow and possibly not well suited to reveal such differences. The nature of the terrain (rural, mountainous, dirt and field in Gran Bois; more urban in Leogone), SES, and behavioral factors may account for these differences.

Gender: Gender differences were not great in this study. Boys did have higher odds for most infections but odds ratios ranged from 1.0 to 1.6 for most worm species and were not statistically significant. The one exception was hookworm infection, with it being more common in girls in Grand Bois (boys had OR 0.55 of that of girls) but again with so few actual infections in the region, this number did not reach statistical significance. Thus, results indicate that gender had no bearing on prevalence of infection with any worms at any intensity, at either study site. There was nothing in the literature to suggest this is an abnormal finding, and it is in agreement with the findings of the Haitian national study conducted by Champetier de Ribes in 2002.

Anemia: The classic presentation of hookworm infection is anemia. In the two data sets hookworm infection was not associated with anemia. This is most likely related to the mild intensity of the few children with this infection and possibly the underlying nutritional and iron status were better than anticipated. There was no difference in the prevalence of hookworm between the study groups (P-value 0.5167) and the average hemoglobin count was normal in both groups as well: 12.7 mg/dl in Grand Bois and 12.4 mg/dl in Leogane). This is a fortunate situation because children with low baseline hemoglobin levels are more prone to more problems when they do get infected with hookworm, as well as with malaria and dengue fever, two other endemic diseases in Haiti.

Anthropometrics: The last set of analyses performed were comparisons of anthropometric Z-scores between study groups, looking for an association between intestinal helminth infections and growth parameters. Height-for-age, weight-for-age, and weight-for-height were chosen, as they are frequently used in pediatric age group studies, and the CDC used them in the Leogane study. They were therefore ideal for comparison purposes. These parameters offer some advantages over the more newly popular BMI measurement. Height-for-age represents genetic height potential but also can be a measure of chronic under-nutrition. Weight-for-age represents both acute and chronic under-nutrition, whereas weight-for-height represents more acute nutritional deficits. It is the one most likely to show a relationship with acute worm infestation defined as one lasting a year or less.

The Z-scores for height-for-age and weight-for-age were statistically lower for Grand Bois subjects than for Leogane subjects. Initially, a plausible explanation was the

higher prevalence and intensity of *Ascaris* infection in the Grand Bois group. *Ascaris* is widely regarded as a major contributor to nutritional deficits, but *Trichuris* and hookworm have been implicated in growth failure as well (Adams, 1994; Guerrant, 2005; Stephenson, 1993a, 1993b; Strickland, 2000). To address this issue, Chi Square was used to compare those in the lowest and highest quartiles of each growth parameter to the prevalence of ascariasis, and to the prevalence of all intestinal helminths combined (Any STH). Results showed no significant differences between the largest and smallest children when considering presence of *Ascaris* or Any STH infection. A potential explanation is that *Ascaris* and other STH infections were not severe enough to impact the physical growth of children. This is contrary to the initial hypothesis of the author and therefore the differences in physical growth measurements between study sites require a different explanation. Difference in nutritional intake is a likely explanation but this was not looked at in this study. Children that are short-for-age but proportionate, as was found in Grand Bois, are considered "stunted", which can result from long-term under-nutrition (Behrman, Kligman, & Arvin, 1996). Another possibility is the caloric expenditure may be far greater in the mountains than by the sea. The people of Grand Bois walk everywhere and carry very heavy loads. In more urban settings there is an informal but extensive mini-bus (or "Tap-Tap") transit system, which mitigates the need to travel by foot.

The ability to study the role of *Trichuris* as it relates to physical growth was hampered by the low numbers of those in Grand Bois infected with this organism. Regardless, the smaller sized children in Grand Bois could not be attributed to an infection as rare as trichiuriasis in that community.

Limitations of Study:

The study has limitations in design, implementation, and analysis. The two study sites are different in many ways (geography, income, services, climate, accessibility, for example). It was not possible to determine which of these factors, if indeed any of them, might be responsible for the differences in results between the two study sites. In addition, the two studies were conducted 10 years apart with many changes taking place in Haiti over that time span.

The Leogane study design involved choosing five schools on a convenience basis within the peri-urban area and enrolling all the students at each school that fit the age range requirements. The Grand Bois research group used random sampling techniques to choose the five schools, but once arriving at them enrolled students on a first come first served basis, which may have introduced bias into the sample. By nature, parents are deeply concerned about the health of their children. When told of the worm study those with abdominal discomfort or a history of worms currently or in the past may have volunteered more readily. Four of the five schools had 48 to 50 students enrolled in the study, while in Mathurin, the most remote and sparsely populated setting in Grand Bois, only 29 students volunteered for the study, which may limit the usefulness of this study site as a comparison to the others. In addition, most subjects in this study were enrolled in school. Thirty to 40% of children in Grand Bois are not enrolled in school on a continuous basis. These children may be at higher risk of infection for socio-economic, behavioral, and exposure reasons. Thus, prevalence may have been underestimated.

The methodologies for determining eggs counts and intensity of infection were different and not directly comparable. In Grand Bois Kato-Katz was used while in

Leogane a modified Stoll technique was chosen; Champetier used yet a third method in the national study. The expertise level of researchers was higher in the Leogane study and more sophisticated diagnostic equipment was used. Sensitivity and specificity for the Kato-Katz technique is highly technician dependent. Over- or under-estimation of egg counts can occur but the most likely error comes in missing light infections, thereby underestimating the true prevalence in a community (Montresor, Crompton, Gyorkos, & Savioli, 2002). The Grand Bois research team did, however, report using inter-observer checks daily throughout the study to improve consistency of reading and thus internal validity of the study (data to compute kappa value not available to this researcher).

Table 26 compares ages of subjects and prevalence of infections between study sites. The age range of students and the average age is different between the groups. The Grand Bois team took some siblings of enrolled students into the study, thus accounting for the three- and four-year-olds. These younger non-students can be different from students in behavior and nutrition, for example. Also, in Grand Bois students over 13 years of age were also enrolled in the study, as many children do not finish primary school until in their late teens. These were excluded in the Leogane study. Interestingly, the Grand Bois study subjects resembled those in the national study much more closely then they did to the Leogane group. Age range for the national study was 3 to 20 years and for the Grand bois group, 3 to 18 years, with the average age almost identical as well. Also, rural areas were included in the national study, which may make its sample more comparable to the Grand Bois sample. As previously noted, very similar prevalence rates for *Trichuris* and hookworm were also obtained, adding credence to the skill of the Grand Bois laboratory analysis and to the quality of the data collected.

Table 26: Age of Subjects and Prevalences of STH as Reported in Three Haitian Cross Sectional Studies

	Grand Bois 2006	Leogane 1996	National 2002
Number in Study	226	978	5792
Age Range (years)	3—18	5—13	3—20
Average Age (years)	9.78	7.45	10
Prevalences			
Ascaris (%)	49.5	30.3	27.3
Trichuris (%)	6.6	43.4	7.3
Hookworm (%)	4.4	7.3	3.8
Any STH (%)	50.9	55.5	34

In summary, the two data sets in this study were not perfectly matched for comparison purposes, and for a number of variables the Grand Bois set was more comparable to the Haitian national study. This was unavoidable given the nature of secondary analysis of two data sets collected by different groups at different times. Unfortunately, no raw data from the national study were available for examination by this author. The primary goals of this study were not affected by this limitation as prevalence and severity of infection and presence of associated morbidities was determined for Grand Bois. The usefulness of the comparison to the Leogane data set is that it generates hypotheses as to the cause of the differences found between the two study sites and opens the door for future study.

Conclusions and Recommendations:

Grand Bois is a remote mountainous tropical region and, as expected, the schoolchildren there have a moderately high prevalence of soil-transmitted helminth eggs in their stools. Infection with *Ascaris* worms predominate with only small numbers of *Trichuris* and hookworm infections identified. Prevalence and intensity did not differ significantly based on age or gender characteristics with a few exceptions. Fortunately, no significant associations were found between STH infection and presence of anemia or growth failure.

The Haitian Ministry of Health is using nation-wide prevalence data as a basis of their deworming program. This is an excellent baseline on which to begin implementation of a national treatment and prevention program but the data do have significant weaknesses in that not all areas of the country have been surveyed. The result

is that resources are not reaching everyone in need. Departement de l' Ouest is reported as having helminthic infection prevalence of 25% (Table 1, p. 23), but this disproportionately represents urban regions over rural ones. This is one of the lower prevalence departments in the country and thus relatively few resources have been allocated for deworming there. This study shows that at least two regions in the department have significantly higher prevalence rates and are in need of deworming programs. Leogane, thanks to a CDC program there, has been participating in community wide deworming for a number of years. Grand Bois has received no such services of this kind to date. Sharing results of the Grand Bois survey with MOH officials may be a first step in beginning a region-wide deworming program.

Thus, based on the results, Grand Bois would be a good candidate for school-based or community-based deworming as outlined in the WHO guidelines discussed. An argument could be made to the contrary, however. First, there were no heavy levels of infection in Grand Bois; all of those falling into the moderate/heavy category were truly moderate infections, and none were even close to reaching the heavy level. Second, there are seemingly few children with morbidity related to their infections, at least in terms of anemia and growth failure rates. Third, even though deworming programs are considered cost effective in many settings, they are not free and do require significant logistical support. Funds and efforts might better be placed elsewhere. Lastly, with such poor sanitation infrastructure, children are likely to get re-infected within a year or two of cessation of any deworming project. An alternate approach is to treat just those presenting with symptoms that lead to a diagnosis of intestinal helminthiasis.

According to WHO guidelines, however, Grand Bois does meet the criteria for a mass deworming program and implementation of such a program is the recommendation of this author. Specifically, a program based in the schools targeting enrolled and un-enrolled children of school age is recommended over an entire community-wide program. This would be easier and cheaper to administer, and according to Chan (1997) it can prevent approximately 70% of the burden of disease in high prevalence communities. Advantages include: 1) reduction of worm burdens lasting up to 18 months with a single treatment, 2) provision of secondary prevention by rapid reduction in associated morbidities, 3) provision of primary prevention by decreasing deposition of STH eggs in stool and thus decreasing potential for transmission of infection to others, and 4) potential reduction in severity of co-morbidities as STH-infected children may have worse outcomes when also infected with HIV/AIDS (Fincham, 2003) and other tropical infections. At current prevalence and severity rates of infection in schoolchildren, once yearly deworming with mebendazole or albendazole is recommended. Follow-up studies should be delayed for two to three years after beginning treatments to assess the program's effectiveness. During this time a concerted effort should be made at hygiene and sanitation education and cost effective infrastructure programs should be sought and implemented if possible. In particular, latrines should be installed in the two schools currently without such facilities.

*Serve*HAITI can play a large role in assisting the St. Vincent de Paul Medical Center and the Ministries of Health and Education with logistical and educational support for a deworming program, but financing for procurement of pharmaceuticals and for staff salaries may require governmental or larger-NGO participation. At an estimated cost of

US 34 cents per child per year and a total population of approximately 66,000, the *financial cost* of full community deworming would be about US $20,000. It would be about one half that for school-based deworming alone given that about 50% of Grand Bois residents are of school age (Central Intelligence Agency, 2006; Ministere De L' Economie Et Des Finances, 2000). The *true economic cost*, however, is the value of missed opportunities (Haddix, Teutsch, & Corso, 2003, pp. 70-71). If resources are used for a deworming program they will not be available for other health improvement projects. This fact should always be considered when implementing a prevention program. In this case, is deworming the best use of the available resources, or are there other more pressing needs in the community? If school-aged children are indeed selected for deworming, every effort should be made to include in the program similarly aged children not enrolled in schools. The WHO has set up strategies to reach these often less-advantaged and possibly more highly infected children (Husein, 1996; Montresor et al., 2002).

Letters to *Serve*HAITI and Haitian MOH officials have been drafted outlining the basic recommendations put forth in this document (Appendices H and I).

Future Study and Challenges:

Based on the findings in this study, several opportunities for further research become apparent. First, perform a more extensive survey of the region, including those children not enrolled in school, and compare them to those who are enrolled. Approximately 30% to 40% of children in the region do not attend school on a regular basis (personal communication, Leopold Bourguoin, 2004), and they may differ from

those who do attend on a number of key factors including place of residence, family income, nutritional status, behavior, and parental educational level, placing them at higher risk for acquiring STH infections. Results of such a study may yield more accurate estimates of community-wide prevalence of disease and thus change frequency recommendations for deworming. Second, why children in Grand Bois are so small bears further investigation. Physical stunting and wasting lead to poor overall health as well as poor school and work performance (Drake, Jukes, Sternberg, & Bundy, 2000; Nokes & Bundy, 1994). Perhaps a detailed nutritional survey and a larger and more precise anthropometric study can be performed. Third, if a deworming program is implemented, follow-up prevalence studies should be planned and should include all of the variables looked at in this study. Fourth, assessment of school performance as it relates to STH infections is a question that was not addressed in this study but one that could be very important. This would require experts in the research and education fields and would be a major undertaking. Fifth, a new comparison study of Grand Bois to a more similar community in the mountains using similar methodologies and selection criteria may be considered. Alternately, accessing the data collected by Champetier in the national study and comparing the mountain communities to Grand Bois may serve a similar purpose. Sixth, designing an experimental study looking at well-matched communities and randomizing one to a pharmaceutical deworming program, one to a sanitation infrastructure program, and one to standard care of treating only those who present with symptoms of STH disease (control), and then comparing the outcomes, would be a difficult but potentially useful study. This could be considered ethical for communities without extremely high burdens of disease like Grand Bois. Seventh,

looking at the prevalence of STH eggs in soil in various communities in the mountains and by the sea could shed light on why there are such large differences in prevalence of STH type in the communities studied. Lastly, looking at STH egg prevalence in stool and soil at different times of the year (rainy, dry, warm, and cold seasons) may give a better estimation of year-round risk of disease. The Leogane and Grand Bois data sets may actually underestimate the true prevalence and intensity of the problem. If higher rates are found at other times of the year more frequent deworming may be advisable.

Many challenges exist from financial, to logistical, to lack of even basic infrastructure. In addition, the development of drug resistance is a consideration over the long term. How likely this is to happen and over what period of time has not been fully answered but evidence in animal populations suggests it does develop and should be watched for carefully in humans (Savioli, 2004). A largely untreated population like in certain rural regions of Haiti may be a good group in which to investigate this question. Ideally, with carefully crafted programs, over-treatment can be avoided and improvement in infrastructure can be accomplished before resistance develops. The challenges that lie ahead for this impoverished community can best be addressed by close collaboration between *Serve*HAITI, the Ministries of Health and Education, and with the input and support of the people of Grand Bois.

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Appendices A through I

Appendix A

ServeHAITI

Bringing Healthcare to the Mountains of Haiti

Dr. Leopold Bourgouin, MD
Dr. Charmaine Lewis, MD
Ms. Wendy Strassner, Esq.
St. Vincent de Paul Health Center
Gran Bois, Haiti and ServeHaiti, Inc., Atlanta, GA

July 14, 2006

John DePasquale, MD
845 Spring St. NE
Unit 414
Atlanta, GA 30308 USA

Dear Dr. DePasquale,

Please be advised that the St. Vincent de Paul Health Center and ServeHaiti, Inc would like you to analyze data that our joint US/Haitian medical team collected in the spring of 2006. This data includes ages, genders, heights, weights, hemoglobin levels, and stool helminth egg counts on 226 pre-school and school-aged children from five randomly chosen schools in the Gran Bois region of Haiti. Our goal is to determine if a school based de-worming program is needed in the region. The data sent to you electronically has no personal subject identifiers connected with it. In addition to clinical data we can provide you with descriptions and photographs of each site and school where the data collection took place and details of methodologies used to analyze blood and stool samples.

Please let us know if we can be of any additional help with your analysis. We look forward to seeing the results and implementing prevention programs if needed. Depending on results, presentation of your report to the Haitian Ministry of Health, with whom we work closely, may aid in establishment of prevention protocols. Studies of prevalence and programs of prevention have been implemented in other parts of the country but up until now no data exists and no prevention programs are in place in Gran Bois.

Thank you for your interest and involvement.

Sincerely yours,

Leopold Bourgouin, MD	Charmaine Lewis, MD	Wendy Strassner, Esq
Medical Director	Team Lead	Executive Director
SVDP Health Center	Soil Transmitted Helminth Study	ServeHaiti
Gran Bois, Haiti	Gran Bois, Haiti and Atlanta, GA	Atlanta, GA

Appendix B[1]

10.7 Kato-Katz Technique (for helminthic prevalence in community)

In order to find out the prevalence and intensity of helminthic infection, Kato Katz technique is used.

10.7.1 Materials and reagents

1. Kato-Katz kit

   The Kit contains

   i) A roll of nylon screen 80 mesh (20m)

   ii) 400 plastic templates with a hole of 6 mm on a 1.5 mm thick template, delivering 41.7 mg of faeces.

   iii) 400 plastic spatula.

   iv) A roll of Hydrophilic cellophane,34 μm thick (20m)

   These kits are available commercially

2. Microscopic slides
3. Flat bottom jar with lid.
4. Forceps.
5. Toilet paper or absorbent tissue.
6. Newspaper.
7. Glycerol-malachite green solution or glycerol-methylene blue solution. Method of preparation is as below:

- (Glycerol…………………………… ………………..100ml
- 3% aqueous malachite green, or
  3% aqueous methylene blue…… ……….. …. 1 ml.
- Distilled water…………………… …………………… 100ml.
  - Grind some malachite green or methylene blue powder with a pestle in a clean,dry mortar, Weigh out 3 gm. Of the powder, pour it into a bottle and add distilled water to give 100ml. Seal and label the bottle: 3% aqueous malachite green or 3% aqueous methylene blue. Store in a cabinet away from light.
  - To prepare the solution: pour 1 ml of the 3% aqueous solution into a 250 ml. bottle. Add 100 ml. of glycerol and 100 ml. of distilled water and seal the bottle; mix thoroughly before use).

10.7.2 Methodology

1. Place a small amount of faecal material on a newspaper/scrap paper and press the small screen on top of the faecal material so that some of the faeces will be sieved through the screen and accumulate on top of the screen.
2. Scrape the flat-sided spatula across the upper surface of the screen so that the sieved faeces accumulate on the spatula.
3. Place template with hole on the centre of a microscope slide and add faeces from the spatula so that the hole is completely filled.
4. Remove the template carefully from the slide so that the cylinder of faeces is left on the slide.
5. Cover the faecal material with the pre-soaked cellophane strip.
6. Invert the microscope slide and firmly press the faecal sample against the hydrophilic cellophane strip on another microscope slide or on a smooth hard surface such as a piece of tile.
7. Carefully remove slide by gently sliding it sideways to avoid separating the cellophane strip or lifting it off. Place the slide on the bench with the cellophane
8. upwards. Water evaporates while glycerol clears the faeces.
9. The smear should be examined in a systematic manner and the number of eggs of each species noted separately.

10.7.3 Quality control for microscopy

1. Quality control is insured to verify the consistency of the microscopic readings. For this one day before the survey is spent on evaluating the consistency of egg counting among the laboratory technicians. A simple method consists of preparing 10 slides and comparing the reading of each slide by each laboratory technician with that of the quality manager. A discrepancy of 5-10% for egg per slide count is normal, but if the discrepancy is larger, the testing is not valid and reasons must be identified and corrected. If one of the technicians presents readings, which are consistently different

[1] From (Montresor, Crompton, Gyorkos, & Savioli, 2002) insertion

Appendix B continued

to those of others, he/she should be excluded from the team. An accurate egg per slide count is particularly important for the Kato-Katz technique for intensity assessment.

2. Besides this, on each day of the survey, one should read 10% of the slides of each technician without prior knowledge of the results independently. In the case of the discrepancy of more then 10%, the slides should be discussed by the two readers. And then further slides may be examined to avoid repeated errors.

10.7.4 Advantage of Kato-Katz technique are as follows

- In Kato-Katz technique a specified quantity of stool is examined, in contrast to STH survey carried out by other methods, where the quantity of stool examined may vary in each slide/sample. Hence any other concentration method is not suitable for comparison of worm load in the different community and further across country estimation.
- Kato-Katz technique is better than other technique for viewing ST

10.7.5 Community categories for community diagnosis

	Community category	**Criteria for classification**
	% of children positive for worm	% of children with heavy intensity infection
I	>70%	10% or more
II	50-70%	Less than 10%
III	Less than 50%	Less than 10%

10.7.6 Community intervention for control of STH

	Community category	**Proposed intervention**
I	High prevalence, High intensity	Treatment 2-3 times a year targeted to all school-age children, IEC, improvement in sanitation, water supply and appropriate waste management
II	High prevalence, Low intensity	Treatment targeted to all school-age children at least once a year, IEC, supporting improvement in sanitation, and waste management
III	Low prevalence, low intensity	Case management, IEC, improvement in sanitation, water supply and appropriate waste management

Appendix C[2]

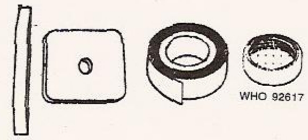
VESTERGAARD FRANDSEN
DISEASE CONTROL TEXTILES

Kato-Katz technique - cellophane faecal thick smear

The Kit contains (Fig. 1)

1. A roll of nylon screen 80 mesh (20 m)
2. 400 plastic templates with a hole of 6 mm on a 1.5 mm thick template, delivering 41.7 mg of faeces
3. 400 plastic spatula
4. A roll of Hydrophilic cellophane, 34 um thick-20 m

Fig. 1



To perform the technique correctly the following materials have to be procured in order

Microscope slides (75 x 25 mm).

Toilet paper or absorbent tissue

Newspaper or scrap paper

Solution of 100 ml of glycerol and 100 ml of distilled water

Flat bottom jar

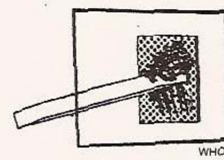
Fig. 2

Preparation

- Cut an appropriate number of pieces of nylon screen 30-35 mm
- Cut an appropriate number of pieces of hydrophilic cellophane of 30-35 mm and place it in the jar.
- Pour the glycerol onto the cellophane strips placed in the jar and leave for at least 24 hours

To increase the visibility of the eggs, 1 ml of 3% aqueous malachite green or 3 % Methylene blue can be added to the glycerol/water solution

Fig. 3

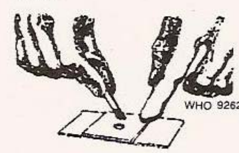


Procedure

1. Place a small amount of faecal material on the newspaper or scrap paper and press a piece of nylon screen on top so that some of the faeces are sieved through the screen and accumulated on top (Fig.2)
2. Scrap the flat-sided spatula across the upper surface of the screen to collect the sieved faeces (Fig.3)
3. Place the template on the center of the microscope slide and add faeces from the spatula so that the hole is completely filled (Fig.4)

   Pass over the template using the side of the spatula to remove excess faeces from the edge of the hole (the spatula and templete may be discarded or reused if carefully washed).
4. Remove the templete carefully so that the cylinder of faeces is left on the slide.

Fig. 4



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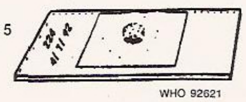
[2] (Vestergaard Frandsen, 2007)

Appendix C continued

VESTERGAARD FRANDSEN
DISEASE CONTROL TEXTILES

Fig. 5



WHO 92621

5. Cover the faecal material with a pre-soaked cellophane strip (fig.5) the strip must be very wet if the faeces are dry and less so if the faeces are soft (if excess glycerol solution is present on the upper surface of the cellophane, *wipe it with toilet paper*). In dry climates, excess glycerol will retard but not prevent drying.

Fig. 6

WHO 92622

6. Invert the microscope slide and press the faecal sample firmly against the hydrophilic cellophane strip on another microscope slide or on a smooth hard surface, such as a piece of tile or a flat stone. The faecal material will be spread evenly between the microscope slide and the cellophane strip (Fig.6). It should be possible to read a newspaper print through the smear after clarification (Fig.7)

Fig. 7

WHO 92623

7. Carefully remove the slide by gently sliding it sideways to avoid separating the cellophane strip or lifting it off. Place the slide on the bench with the cellophane upwards. Water evaporates while the glycerol clears the faeces.
8. For all except hookworm eggs, keep slide for one or more hours at room temperature to clear the faecal material, prior to examination under the microscope. To speed up clearing, the slide can be placed in a 40°C incubator or kept in direct sunlight for several minutes.
9. Ascaris lumbricoides and trichuris trichiura eggs will remain visible and recognizable for many months in these preparations. Hookworm eggs clear rapidly and will no longer be visible after 30-60 minutes. Schitosome eggs may be recognizable for up to several months but it is preferable in a schistosomiasis endemic area to examine the slide preparations within 24 hours.
10. The smear should be examined in a systematic manner and the number of eggs of each species reported. Later, multiply this number by 24 to obtain the number of eggs per gram of faeces **(epg.)**
11. The epg gives an estimation of the worm burden and allow to identify individuals likely to suffer from severe consequences of the infection (i.e. those with heavy intensity infections)

The following thresholds for the classification of individuals are proposed by WHO. Some flexibility in setting thresholds may be necessary depending on local epidemiological characteristics.

	Light intensity infections	**Moderate intensity infections**	**Heavy intensity infections**
A. lumbricoides	1 - 4,999 epg	5000 - 49,999 epg	≥ 50,000 epg
T. trichiura	1 - 999 epg	1000 - 9,999 epg	≥ 10,000 epg
*Hookworms**	1 - 1,999 epg	2000 - 3,999 epg	≥ 4,000 epg
S. mansoni *S. japonichum*	1 - 99 epg	100 - 399 epg	≥ 400 epg

- *Control of schistosomiasis* (1993) Second report of WHO Expert Committee
- *Control of intestinal parasitic infection* (1987) Report of Who Expert Committee
- *Guidelines for the evaluation of soil-transmitted helminthiasis and Schistosomiasis at community level* (1998)

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Appendix D

SOIL-TRANSMITTED HELMINTHIASIS AND SCHISTOSOMIASIS
SCHOOL SURVEY

SCHOOL FORM

to be completed by the survey team

School ______________________ Date __/__/____

Region ______________________ District ______________________

Composition

Total number of schoolchildren ________ Number of girls* ________

Number of classes ________ Number of teachers ________

Water

Is there a water source in the school? Yes ☐ No ☐

Type of water source ______________________

Are there water sources close to the school? Yes ☐ No ☐

Type(s) of water source ______________________

Sanitation

Are there latrines in the school? Yes ☐ No ☐

Condition of latrines ______________________

Health

Nearest health facility ______________________

Type ______________________ Distance ______km

Treatment

Number of children treated for soil-transmitted helminthiasis:

Enrolled ________ Non-enrolled ________

Number of children treated for schistosomiasis:

Enrolled ________ Non-enrolled ________

Appendix E

SOIL-TRANSMITTED HELMINTHIASIS AND SCHISTOSOMIASIS
SCHOOL SURVEY

CHILD FORM
PARASITOLOGICAL/NUTRITIONAL DATA

to be completed by the survey team

Personal data Date __/__/____

ID Number ____________________ School (or village) ____________________

Name ____________________ Age _____ years________ Sex M☐ F☐

Nutritional data

Weight __________kg Height __________cm Hb __________g/dl

Anaemia (Hb < 11 g/dl) Yes ☐ No ☐ Severe anaemia (Hb < 7 g/dl) Yes ☐ No ☐

Parasitological data

(a) Stool examination	eggs/slide	eggs/gram (epg)	Moderate/heavy-intensity threshold	Moderate/heavy-intensity infection	
				Yes	No
Ascaris lumbricoides			≥5000 epg		
Trichuris trichiura			≥1000 epg		
Hookworms			≥2000 epg		
Schistosoma mansoni			≥100 epg		
S. japonicum			See note		
Other parasites identified					

(b) Urine, visual examination	Present	
	Yes	No
Visible haematuria		
Microhaematuria (using reagent strips)		

(c) Urine, examination by microscope	eggs/10 ml of urine	Heavy-intensity threshold	Heavy-intensity infection	
			Yes	No
Schistosoma haematobium (filtration)		≥50 eggs/10 ml		

Note: For *S. japonicum*, any intensity of infection is considered to be heavy.

Appendix F

SOIL-TRANSMITTED HELMINTHIASIS AND SCHISTOSOMIASIS
SCHOOL SURVEY

DRUG DISTRIBUTION FORM FOR <u>ENROLLED</u> SCHOOL-AGE CHILDREN

to be completed by the teacher during each treatment day

School name ____________ Location ____________ Class ____________

Teacher ________________ Region ____________ District ____________

Health education activities performed? Yes ☐ No ☐

Describe health education activities on the reverse side of this form →

	Names of enrolled children, from class roster	Sex		Drug administered					
		M	F	1st round date __/__/__		2nd round date __/__/__		3rd round date __/__/__	
				PZQ*	ALB	PZQ*	ALB	PZQ*	ALB
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									
Number of children enrolled									
Number of children treated									
Total quantity of drug used									

*For praziquantel (PZQ), indicate the number of tablets given to each child.

Appendix G

SOIL-TRANSMITTED HELMINTHIASIS AND SCHISTOSOMIASIS
SCHOOL SURVEY

DRUG DISTRIBUTION FORM FOR NON-ENROLLED SCHOOL-AGE CHILDREN

to be completed by the teacher during each treatment day

School name ____________ Location ____________ Date __/__/_______

Teacher _______________ Region ______________ District ___________

Name of child receiving treatment		Sex		Age	Drug administered	
		M	F		PZQ*	ALB
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
Number of children treated						
Total quantity of drug used						

*For praziquantel (PZQ), indicate the number of tablets given to each child.

Appendix H

Leopold Bourgouin, MD
Charmaine Lewis, MD
Wendy Strassner, JD
*Serve*HAITI
999 Peachtree St. NE, #2300
Atlanta, GA 30309

31 April 2007

John DePasquale, MD
c/o Georgia State University
845 Spring St. NW, Unit 414
Atlanta, GA 30308

Dear Drs. Leopold and Lewis, and Ms. Strassner:

Thank you for the work you do in Haiti on behalf of the people of the Grand Bois region of Departement de l'Ouest. In particular thank you for conducting the Soil-Transmitted Helminth (STH) survey of that region in March 2006 and for asking me to analyze the data your team collected. As part of my thesis I also analyzed a set of data made available to me by the Centers for Disease Control and Prevention in Atlanta. This data was collected in the coastal town of Leogane, Haiti in 1996 and served as a comparison to the data you provided.

The World Health Organization (WHO) categorizes severity of infections as mild, moderate and heavy. Data from your survey revealed that 50.9% of children were infected with at least one STH (also known as geohelminths) and that 8.8% had moderate severity of infection. Most infections were secondary to *Ascaris lumbricoides*, the most common cause of human worm infections worldwide. The numbers were significantly higher for the school at Mathurin with 20.7% of children with moderately severe *Ascaris* infections. The school at Palmes had 75.5% of the children positive for *Ascaris* and 14.3% with moderate severity infections. Of note, neither of these schools had latrines for student use, while the other three lower-prevalence schools in the study did. It is encouraging that whipworms and hookworms have minimal prevalence (<10%) and only mild severity amongst the children in this region.

Girls and boys were equally affected by geohelminths, and the overall prevalence did not differ by age. Of note, the intensity of ascariasis did differ with age, with children less than 10 years three times more likely to have moderately severe infections. Of the few children with hookworm infection no association was found with presence of anemia, which is good news. This may be due the light degree of infection in the few affected children. Another positive point is that children with ascariasis were no smaller than children without this infection for the three growth parameters measured: height-for-age, weight-for-age, and weight-for-height. Of note, the children in Grand Bois are

significantly smaller than children in Leogane for both height- and weight-for-age measures. This may warrant further investigation.

Although Departement de l'Ouest has an overall prevalence of STH infection of 25%, there are pockets with much higher prevalence, with significant numbers of children with moderate degrees of infection. Grand Bois is one such region. Thus, in accordance with WHO recommendations I would suggest you institute a school- or community-wide deworming program for the Grand Bois area, as the overall prevalence of worms in the region is between 50% and 70% and the prevalence of moderate to severe infections is close to 10%. At these levels, once yearly treatment of all school-aged children with albendazole 400mg or mebendazole 500mg is suggested, with follow up prevalence studies to be conducted after three years. I know deworming protocols vary by country, and realize the Ministry of Health has done good work deworming other regions over the past few years. You will need to check and possibly follow their national guidelines and work with the various ministries to coordinate services.

I would be happy to make available my complete analysis and formal recommendations and to meet with you in person to further discuss your work and possible implementation of a formal deworming program. Attached please see a summary list of recommendations.

Sincerely,

John DePasquale, MD and MPH student
Georgia State University
Atlanta, GA, USA

Summary of Recommendations:

1) Deworm schools once yearly
2) Deworm everyone attending all the schools in the region, not just the five schools in your study, and not just certain age or gender groups within the schools. Include local children not enrolled in school as well.
3) If you plan to conduct a post-treatment survey allow two to three years to pass before doing so. This is in accordance with WHO guidelines so as to best see the potential benefits of your intervention.
4) Post treatment survey should be conducted on the same five schools as used in the initial survey.
5) An alternate approach, if you have the resources, is to deworm the entire community, including adults and preschoolers. This will serve to help break the cycle of worm eggs entering the environment and then re-infecting the people. It will provide primary prevention against new infection to a greater extent than treating school-aged students alone.

6) While doing yearly deworming, work on sanitation infrastructure improvement since two schools in Grand Bois do not have latrines, others are in poor repair, and most do not have hand-washing facilities.
7) Concurrent with deworming, institute hygiene education in the schools
8) Seek ways to increase the use of foot-ware among children and women to decrease the risk of acquiring hookworm disease.
9) Investigate the causes of growth failure among children in Grand Bois.

Appendix I

Ministry of Health
Republic of Haiti
c/o Dr. Leopold Bourgoin
Grand Bois, Haiti

31 April 2007

John DePasquale, MD
c/o *Serve*HAITI and Georgia State University
845 Spring St.
Atlanta, GA 30308
USA

Dear Doctor,

*Serve*Haiti, an Atlanta based non-governmental organization, has been working in Grand Bois for the past 10 years with Pere Boniface at St. Pierre Catholic Church and with Dr. Leopold Bourgoin at the St. Vincent de Paul Medical Center. In 2006 *Serve*Haiti was asked by Dr. Leopold to conduct a geo-helminth prevalence study, for he noted many children with worms and had one death due to intestinal obstruction. *Serve*Haiti, employing a joint US/Haitian medical and public health team, carried out this survey by randomly choosing five schools in the region and studying approximately 50 students from each school. This was done in accordance with World Health Orogranization (WHO) protocols. Headmasters of each school agreed to the survey, parents gave verbal consent, and 229 students volunteered to participate. In July of 2006 Dr. Bourgoin and the directors of *Serve*HAITI asked me to analyze the results and make recommendations. I agreed to analyze the data as part of my public health training program at The Georgia State University, Institute of Public Health.

The WHO categorizes severity of infections as mild, moderate and heavy. Data from your survey revealed that 50.9% of children were infected with at least one STH (also known as geohelminths) and that 8.8% had moderate severity of infection. Most infections were secondary to *Ascaris lumbricoides*, the most common cause of human worm infections worldwide. The numbers were significantly higher for the school at Mathurin with 20.7% of children with moderately severe *Ascaris* infections. The school at Palmes had 75.5% of the children positive for *Ascaris* and 14.3% with moderate severity infections. Of note, neither of these schools had latrines for student use, while the other three lower-prevalence schools in the study did. It is encouraging that whipworms and hookworms have minimal prevalence (<10%) and only mild severity amongst the children in this region.

Girls and boys were equally affected by geohelminths, and the overall prevalence did not differ by age. Of note, the intensity of ascariasis did differ with age with children less than 10 years three times more likely to be moderately severely infected. Of the few children with hookworm infection no association was found with presence of anemia, which is good news. This may be due the light degree of infection in the few affected children. Another positive point is that children with ascariasis were no smaller than children without this infection for the three growth parameters measured: height-for-age, weight-for-age, and weight-for-height. Of note, the children in Grand Bois are significantly smaller than children in Leogane for both height- and weight-for-age measures. This may warrant further investigation.

Although Departement de l'Ouest has an overall prevalence of STH infection of 25%, there are pockets with much higher prevalence, with significant numbers of children with moderate degrees of infection. Grand Bois is one such region. Thus, in accordance with WHO recommendations, I would suggest institution of a community-wide deworming program for the Grand Bois area as the overall prevalence of worms in the region is between 50% and 70% and the prevalence of moderate to severe infections is close to 10%. At these levels, once yearly treatment for all school-aged children with albendazole 400mg or mebendazole 500mg is suggested with follow up prevalence studies to be conducted in three years. I know deworming programs vary by country protocol and realize Haiti has done good work addressing this health concern in other areas of the country over the past few years. You may have a different protocol.

Please be advised that *Serve*Haiti would like to help the Ministry of Health and Dr. Bourgoin bring a deworming program to the Grand Bois area. Please let them know of any way they can be of assistance to you. Lastly, *Serve*HAITI directors agree to make the data available to you and I am happy for you to review the data analysis if you like.

Sincerely,

John DePasquale, MD and MPH student
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marcodep@mac.com
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