INTERNATIONAL
MEDICAL
OUTREACH

Rapid Appraisal on
Soil-transmitted helminthiasis (Intestinal parasites) in

Croix-des-Bouquet, Haiti

August 2015

Preface

An International Medical Outreach (IMO) team collected the data used in this report and reached the conclusions presented under the direction of Dr. Todd M. Price, IMO Director. The team measured the height and weight of the children tested and collected the stool samples and blood samples used in the study. They also conducted the stool analysis and blood analysis on site in Croix-des-Bouquet, Haiti.

Questions or comments on the study can be directed to info@imoutreach.com.

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Introduction

Soil-transmitted helminthiasis (STH) refers to a set of parasitic diseases caused by a group of intestinal worms collectively called soil-transmitted helminths (STHs) that are transmitted primarily through contaminated soil. Approximately two billion people worldwide are infected with STHs and an additional four billion are at risk. Of these, children are most susceptible to infection due to their frequent exposure to a contaminated environment through playing, eating raw vegetables and fruits, and direct contact with soil and water. Heavy infections of STHs decrease nutritional status, affect school performance, and lower resistance to other infectious diseases while chronic infections lead to malnutrition, stunted growth, and diminished intellectual capacity.

Explanation of Rapid Appraisal

In August 2015, an International Medical Outreach team conducted our own independent testing for STH in Croix-des-Bouquet, Haiti. This independent testing, or Rapid Appraisal, measured a sample group of children throughout the area on six parameters: stool analysis, height, weight, and blood analysis that includes testing for the incidence of anemia, malaria, and HIV. These parameters are described below.

Stool Analysis

Microscopic examination of a simple stool smear is sufficient in diagnosing STH because of the enormous daily output of eggs by gravid female worms. The procedure is simple: collect a fresh (same day) stool sample, prepare slide, examine sample under a microscope, and record findings. This process of observing and identifying eggs in the feces under a microscope is enough to determine the presence of ascariasis, enterobiasis, hookworm infection, and strongyloidiasis and can be performed on site, given that there is a power source for the microscope.

Height and Weight

Children are highly susceptible to dietary deficiencies that lead to malnutrition. Chronic malnutrition can cause a higher susceptibility to disease, a significant drop in IQ, and stunted physical growth. Interpretation of measurements of height and weight for children in relation to a standard growth chart is essential to confirm a child's healthy growth and development. An International Growth Chart released by the World Health Organization depicts the growth of children from birth to 5 years who had been raised in six different countries (Brazil, Ghana, India, Norway, Oman, and USA) according to recommended nutritional and health practices. After the age of five, the WHO recommends the use of the United States Center for Disease Control (CDC) charts. The optimal growth displayed in these growth charts represents the prescribed gold standard for children's growth or the way all healthy children should grow.

The internationally recommended way to assess malnutrition at population level is to take body or anthropometric measurements (weight and height) and consider these in relation to each other. Weight alone has little meaning unless it is related to a child's age or height. The WHO recommends using this data to monitor trends.

The measurements collected for each child are used to determine percentiles of height-for-age, weight-for-age, and body mass index. For example, when a child's weight-for-age is plotted at the 95th percentile line, it means that 5 out of 100 children (5%) of the same age and sex have a higher weight. These percentiles reveal the balance among those falling in the top-tenth and bottom-tenth of the tested population. They also reveal the prevalence of stunting (defined as children with height-for-age below the 5TH percentile), underweight (defined as children with weight-for-age below the 5TH percentile), and wasting (defined as children with body mass index below the 5TH percentile).

Results of Rapid Appraisal

Stool Analysis

Soil-transmitted helminthiasis

	NUMBER TESTED	NUMBER POSITIVE	PREVALENCE
Total	**89**	**50**	**56.2%**
Girls	**35**	**21**	**60.0%**
Below 12 years old	21	15	71.4%
12 years and older	14	6	42.9%
Boys	**46**	**29**	**63.0%**
Below 12 years old	26	19	73.1%
12 years and older	20	10	50.0%

- 56.2% represents a high overall prevalence.
- Only one slide per stool sample was examined. Thus, the prevalence of STH infections observed in this study might have been underestimated.
- WHO recommends mass treatment twice per year.
- For both boys and girls, the older children have a lower prevalence than the younger children. is a higher prevalence in the younger group compared to the older group (71.4% v 42.9%)

Four types of helminths were found: Hookworm, Pinworm, Roundworm, and Whipworm. These types are described in detail starting on page 13. The distribution of each helminth among those testing positive is represented below.

TYPE OF HELMINTH	NUMBER POSITIVE	PREVALENCE
Hookworm	26	29.2%
Pinworm	3	3.4%
Roundworm	23	25.8%
Whipworm	1	1.1%
More than one species	3	3.4%

- Four types of helminths are identified, with 3.4% of the tested population having more than one type.
- Hookworm and Roundworm are the most prevalent with no significant difference between the two.
- Hookworm is the most common (29.2%) helminth found within this community.
    - Open defecation and poor sanitary conditions are the main causes of high prevalence.
    - The larvae enter the body by penetrating the skin usually through the bottom of the feet.
    - Major manifestation of hookworm infection is anemia.
- Roundworm is the second most common (25.8%) helminth.
    - Associated with poor personal hygiene and hand washing practices.
    - Transmitted by the ingestion of eggs from contaminated soil, water, and raw fruits and vegetables.
    - The most important consequence of ascariasis is the impact on physical and intellectual development.
- Pinworm is third most common (3.4%)
    - There may be no symptoms other than itching in the anal and rectal area
    - Pinworm infections are spread from person to person. Children scratch the rectal area, get eggs on their fingers or under their fingernails, and transport the eggs to bedding, clothing, and other items and other people.
    - Good hand washing practices, especially under the fingernails, will reduce the spread.
- Whipworm is the fourth most common (1.1%)
    - Infection occurs through ingestion of eggs.
        - Eggs are deposited into the soil through open defecation.

        - Fingers are contaminated from contact with the soil or contact with fruits and vegetables not properly washed or cooked.
    - Risk factors for whipworm are a hot, humid climate and poor sanitation and hygiene practices.

Height and Weight

Height-for-age

		BOTTOM 10TH PERCENTILE		TOP 10TH PERCENTILE	
	NUMBER TESTED	NUMBER	PERCENTAGE	NUMBER	PERCENTAGE
Total	**81**	**39**	**48.1%**	**2**	**1.2%**
Girls	**35**	**14**	**40.0%**	**1**	**2.9%**
Below 12 years old	21	8	38.1%	1	4.8%
12 years and older	14	6	42.9%	0	0.0%
Boys	**46**	**25**	**54.3%**	**1**	**2.2%**
Below 12 years old	36	13	50.0%	1	3.8%
12 years and older	20	12	60.0%0	0.0	%

Weight-for-age

		BOTTOM 10TH PERCENTILE		TOP 10TH PERCENTILE	
	NUMBER TESTED	NUMBER	PERCENTAGE	NUMBER	PERCENTAGE
Total	**81**	**40**	**49.4%**	**1**	**1.2%**
Girls	**35**	**14**	**40.0%**	**1**	**2.9%**
Below 12 years old	21	10	47.6%	1	4.8%
12 years and older	14	4	28.6%	0	0.0%
Boys	**46**	**26**	**56.5%**	**0**	**0.0%**
Below 12 years old	26	17	65.4%	0	0.0%
12 years and older	20	9	45%	0	0.0%

- Almost 50% of all children tested fall in the bottom 10th percentile, indicating abnormal growth.
- 40% of all girls were in the bottom 10th percentile
    - Of the older girls, 42.9% were in the lower 10th percentile
    - Of the younger girls, there were less, albeit still significant amount in the lower 10th percentile at 38.1%
- 54.3% of all boys were in the lower 10th percentile
    - 60% of the older boys were in the lower 10th percentile
    - 50% of the younger boys were in the lower 10th percentile
- 40% of all girls were in the bottom 10th percentile
    - The older girls fared better (28.6% v 47.6% in the bottom 10th percentile)
- 56.5% of all boys were in the bottom 10th percentile
    - Likewise the older boys were better than the younger boys (45% v 65.4%)

Stunted, Underweight, Wasting

	STUNTED	UNDERWEIGHT	WASTING
Total	**34.6%**	**40.7%**	**33.3%**
Girls	**28.6%**	**31.4%**	**22.9%**
Below 12 years old	33.3%	38.1%	33.3%
12 years and older	21.4%	21.4%	7.1%
Boys	**39.1%**	**47.8%**	**41.3%**
Below 12 years old	30.8%	57.7%	53.8%
12 years and older	50.0%	35.0%	25.0%

- Extremely high prevalence of children of both sexes in the both the stunted and underweight categories (34.6% stunted v 40.7% underweight)
- This would indicate that the amount of nutrition for the proper mental and physical development of the children in these communities is compromised.
- There is a direct correlation between parasite prevalence and the height-for-age, weight-for-age, and stunting data regarding girls v boys (the boys with a higher parasite prevalence also had a higher chance of weighing less, being of shorter stature, and being stunted.
- Within girls, the parasite prevalence directly correlated with weight-for-age and stunting (but did not correlate with height-for-age, yet there was little difference among the age groups in this category)
- Within boys the prevalence of parasites directly correlated with the weight-for-age data

Parasite Prevalence by Venue and Species

			DISTRIBUTION OF SPECIES AMONG THOSE TESTING POSITIVE				
	NUMBER TESTED	ALL SPECIES	HOOK WORM	PIN WORM	ROUND WORM	WHIP WORM	MORE THAN ONE TYPE
Compassion pour Tous	16	93.8%	31.3%	0.0%	75.0%	0.0%	12.5%
Bousol Timoun	42	35.7%	30.9%	0.0%	4.8%	0.0%	0.0%
La Semence	31	64.5%	25.8%	9.7%	29.0%	3.2%	3.2%

Soil-transmitted Helminthiasis (STH) Explained

1.1 Causative Agents

Amoeba (*Entamoeba histolytica*)

About 40 – 50 million worldwide are currently infected with *Entamoeba histolytica*, a protozoa which causes Amoebiasis. It is endemic in most countries with low socioeconomic conditions. Infection occurs via the fecal–oral route and therefore it is especially prevalent in locations where human feces are utilized for fertilizer, or where raw sewage contaminates the water supply. Cysts are infective in freshwater, seawater, sewage and wet soil and can remain infective for several days in feces. Cysts survive for up to 45 minutes in fecal material lodged under the fingernails. Food-borne outbreaks of disease occur when infected food handlers use unsanitary practices. It can also be transmitted sexually.

When cysts are swallowed, they hatch thus releasing the trophozoite in the digestive tract. Once the mucus barrier of the colon has been broken down, the trophozoites produce superficial erosion. Sometimes, the trophozoites enter capillaries, and are transmitted by the blood stream to the liver, or to other organs where they cause abscesses.

Lower abdominal discomfort with loose bowel movements or watery diarrhea may be the presenting symptoms. In more severe cases, stools are bloodstained with mucus. Small superficial flat or oval ulcers (3–5 mm in diameter) separated by normal mucosa may be scattered throughout the colon, or there may be diffuse inflammation. Ulcers may penetrate blood vessels, causing bleeding, or could perforate the colon leading to peritonitis. Extensive ulceration may lead to necrosis of the colon, at which time the bowel is dilated, and the patient is extremely febrile and toxic. An amoeboma, or amoebic granuloma, may result from repeated invasion of the colon with trophozoites, superinfected with pyogenic bacteria.

Fever is present in most cases, with rigors and profuse sweating. Anorexia, weight loss, nausea, vomiting and fatigue may all be present. But the cardinal sign of amoebic liver abscess is abrupt pain. Movement of the right side of the chest and diaphragm is restricted and there is hypoventilation of the right lower lobe of the lung.

The time-honored diagnostic test is actually viewing the trophozoites in the process of ingesting red blood cells in stool microscopy. However, this is positive in only 10% of cases. Otherwise, stool antigen tests or blood antibody tests are useful in screening and confirming the diagnosis in a patient with consistent clinical symptoms.

A specific antibody response is present in 85–95% of patients with invasive disease, but in endemic areas many patients with recent infection, or with asymptomatic infection, will also have positive serology. The results of serological tests may be negative in patients who present acutely and should be repeated in 5–7 days.

Metronidazole or tinidazole are the drugs of choice for amoebic colitis as well as for liver abscesses. Surgery should be reserved only for patients with rupture of the abscess or when bacterial superinfection occurs.

Only by improving sanitation (a safe water supply, adequate disposal of feces, food safety and health education to prevent fecal–oral transmission), and by early diagnosis and treatment of individual cases, will the incidence of amoebiasis decrease.

Hookworm (*Necator americanus* and *Ancylostoma duodenale*):

Hookworms affect approximately 576 million people globally and is the leading cause of maternal and child morbidity in developing countries of the tropics and subtropics. Infective hookworm larvae penetrate human skin through hair follicles and small fissures within minutes of contact with contaminated soil. The larvae are carried by circulation to the lungs, penetrate the alveolar walls, and make their way up the trachea to be swallowed and carried to their final habitat in the small intestine.

Migration of larvae through the lungs may provoke the inflammation of lung tissue. Once in the intestine, hookworms may cause chronic abdominal pain and persistent eosinophilia. The major manifestations of hookworm infection, however, are iron-deficiency anemia and protein energy malnutrition resulting from blood loss. Features of hookworm-induced anemia include smaller than normal red blood cells that are poorly filled with hemoglobin, skin paleness, weakness, physical or mental weariness, lack of energy, difficulty or uncomfortable breathing, and swelling of the organs due to an abnormally low level of protein in the blood, especially in malnourished children. Moderate infections

and anemia can impair physical, cognitive, and intellectual growth in children, diminish productivity of workers, and threaten the outcome of pregnancy for both mother and child. The development of anemia depends on the intensity and duration of the infection, yet in the most sever cases, anemia caused by hookworms can lead to congestive heart failure.

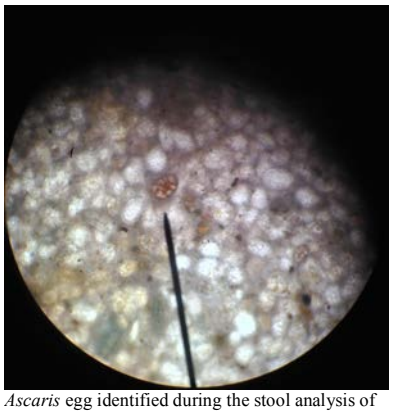
Pinworm *(Enterobius vermicularis)*:

Pinworm, called *Enterobius vermicularis*, is highly prevalent throughout the world and is particularly common among children. Pinworms are small, thin, white roundworms that reside in the large intestine, appendix, and adjacent gut. Female worms, containing an average of 10,000 ova at a time, migrate to the perianal and pelvic regions where they deposit their eggs and die. The eggs become infective within six hours and are transferred to clothes, bedding, dust, and air. The most common mode of transmission, however, is via the hands of the host, particularly underneath the fingernails, through scratching or handling clothes and bed linen. On ingestion, the embryos hatch in the duodenum, molt twice, and develop within five or six weeks into adult worms that live for about a month.

Enterobiasis, or pinworm infection, is not associated with any particular social class, gender, race, or culture. The prevalence of enterobiasis is lowest in infants and reaches its maximum in schoolchildren from five to fourteen years old. Pinworm eggs are infective within six hours of the time that they are laid and may remain so for up to twenty days. Pinworm is primarily a familial or institutional infection associated with crowding. Because of the relatively brief life span of the worms, long-standing infections are due to continuous reinfection.

Most pinworm infections are asymptomatic; however, symptoms that do appear are largely related to perianal and pelvic itching and scratching. Painful urination, inability to control urine, vaginal infection, and vaginal discharge can also occur due to pinworm. The migration of the parasite may also lead to pelvic, cervical, vulvar, and kidney inflammation. Large numbers of larval pinworms have caused inflammation of the digestive tract in both adults and children.

Roundworm *(Ascaris lumbricoides)*:



Ascaris egg identified during the stool analysis of IMO's Rapid Appraisal in El Paraiso.

Ascaris is the most common form of STH, affecting about 800 million to 1.2 billion people globally. Ascariasis is transmitted by the ingestion of infective eggs from soil, water, or vegetables that have been contaminated with the feces of already infected persons. Once ingested, the eggs hatch in the intestines, burrow through the gut wall, and migrate via venous blood through the liver and heart to the lungs. There they break into the alveoli. Once mature, they pass up to the trachea where they are coughed up and swallowed. The larvae then pass through the stomach for a second time into the intestine where they become adult worms. A single worm has a life span of one to two years and may produce two hundred thousand eggs a day. The high prevalence of ascariasis worldwide is a consequence of the tremendous egg output from female worms and the remarkable ability of ova to resist unfavorable external environments.

As *Ascaris* travel through the body, they can cause visceral damage, peritonitis and inflammation, enlargement of the liver or spleen, and an inflammation of the lungs. They may also cause coughing or gagging, vomiting, wheezing, or shortness of breath. Once the worms make it to the intestine, they steal nutrients from the partially digested host food and cause malabsorption, contributing to malnutrition. They may also cause gastrointestinal discomfort, nausea, irregular stools, stomach or abdominal pain, weight loss, fatigue, and fever. Ascariasis has been shown to depress appetite and food intake by children and can interfere with absorption of proteins, fats, lactose, vitamin A, and iodine. The impact on nutrition, intellectual development, cognitive performance, and growth is likely the most important health related consequence of ascariasis worldwide. Treatment of heavily infected children with anthelmintics has been shown to improve nutritional status, but provision of micronutrients, protein, and energy is necessary for underweight or stunted children to achieve catch-up growth.

Ascariasis is associated with poor personal hygiene and poor sanitation, including places where there are no latrines or other sanitation infrastructure. Preventative measures taken against ascariasis include avoiding the ingestion of soil that may be contaminated with human feces; washing hands with soap and warm water before handling food; teaching children the importance of washing hands to prevent infection; and washing, peeling, or cooking all raw vegetables and fruits before eating, particularly those that have been grown in soil that has been fertilized with

manure. Not defecating outdoors and establishing effective sewage disposal systems can also prevent the transmission of ascariasis.

Schistosomiasis *(Schistosomiasis)*:

Although calcified Schistosomiasis eggs have been found in 3,000-year-old Egyptian mummies and a 2,000-year-old Chinese corpse found in the Hunan Province, it remains, after malaria, the second most serious parasitic disease in the world. The World Health Organization estimates that over 700 million are at risk, over 200 million persons are currently infected, 20 million have severe disease, and 100,000 die each year.

Transmission of schistosomiasis requires an appropriate snail intermediate host, fecal or urinary contamination of warm slowly moving fresh water, and human entry into snail-infested water. When humans wade or bathe in fresh water, free-living, cercarial larvae that are released by the parasite's intermediate hosts – aquatic or amphibious snails – penetrate the skin. After penetration, the cercariae lose their tails and change into schistosomula, which migrate to the lungs and liver. In about 6 weeks, they mature to adult worms and descend through the venous system to their final habitat. Adult worms live, mate, and feed on blood in vessels of the gastrointestinal tract or those closely associated with the urinary bladder. The male worm folds around and encloses the female, which produces between 300 to 3,000 eggs per day dependent upon the species. About half of the eggs make their way into the urine or feces and hatch in fresh water, where the miracidium, a ciliated larva, emerges and then penetrates the body of the appropriate snail intermediate host and multiplies asexually. Within 4 to 6 weeks, thousands of motile cercariae emerge. Eggs appear in the feces or urine about 4 to 6 weeks after cercariae penetrate the skin. Adult schistosomes live on the average of 3 to 5 years but can survive for 30 years or more.

Because worms do not multiply in the host, the intensity of the infection depends on the number of cercariae encountered. The signs, symptoms, and complications of the disease is due solely to the host's immune response to the larvae and eggs, since the adult worm cannot be detected by the host's immune system. Eggs that pass into the environment also have little to do with the disease. But the eggs that are trapped in the tissues (approximately half of the eggs that are produced), which can survive for up to 6 weeks, cause an immune response.

Schistosome dermatitis occurs when cercariae penetrate the skin, causing urticarial followed by a macular rash several hours later. In persons exposed for the first time, this rash disappears quickly, but in previously sensitized persons, it may persist and progress to a pruritic maculopapular rash that lasts for days. Because exposure typically occurs by walking or wading in infected ponds or rivers, the rash in usually located on the lower legs. The rash is most severe in persons infected with schistosomes of birds or aquatic mammals, which die in the skin.

Acute schistosomiasis is most likely to occur in the previously unexposed traveler or new immigrant to an endemic area. While symptoms usually resolve over several weeks, intense infection may result in death. Symptoms develop between 4 and 8 weeks of exposure, coinciding with the beginning of egg production. Fever, sweats, chills, cough, and headaches are typical symptoms while physical findings include lymphadenopathy and hepatosplenomegaly. Early in the course, routine fecal parasitologic diagnosis is often negative due to the early absence or limited numbers of eggs passed in the stool. Serologic testing or, less commonly, rectal or bladder biopsies may be required to establish the diagnosis.

Chronic schistosomiasis is due to an exaggerated immune response to parasite eggs resulting in chronic scarring and obstruction in the intestine or portal veins (*S. mansoni*, *S. japonicum*, *S. mekongi*, and *S. intercalatum*) or the urinary tract (*S. haematobium*). Chronic disease is associated with renal and bladder dysfunction or liver and intestinal disease, it is a contributing cause of anemia and growth retardation, and has been postulated to be a risk factor for certain types of cancers.

Those with intestinal disease may experience fatigue, abdominal pain, diarrhea, or dysentery. Persistent inflammation contributes to anemia of chronic disease, while, in more advanced disease, ulceration and chronic bleeding may lead to moderate or sever iron-deficiency anemia. If parasite eggs travel to the liver via the portal circulation, scarring can lead to fibrosis, portal vein hypertension and the development of hepatomegaly and ultimately splenomegaly.

Deposition of eggs around the lower end of ureters and in the wall of the urinary bladder results in hematuria, dysuria, and urinary frequency. Bladder neck obstruction can lead to hydroureter and hydronephrosis, a set up for repeated bacterial infection, compromised kidney function, and finally renal failure and squamous cell bladder carcinoma.

Other clinical manifestations are dependent upon the location of egg deposition. Among the most significant are pulmonary, central nervous system (CNS), renal, and cutaneous manifestations. Pulmonary schistosomiasis results

in shortness of breath, either at rest or upon exercise; and CNS schistosomiasis causes grand mal epilepsy and transverse myelitis.

The “gold standard” for diagnosing schistosome infection is to detect eggs in the stool. Parasite eggs can also be identified in the tissues (rectal, intestinal, liver, prostatic, cervical, or bladder biopsy). The characteristic feature of the *S. mansoni* egg is its lateral spine; of the *S. haematobium*egg, its terminal spine; and of the *S. japonicum* egg, its limited, inconspicuous spine.

A positive serology does not distinguish between current and past infection in endemic populations. In these, negative serology is useful in excluding infection. However, among travelers from non-endemic areas who have only a recent, brief, defined exposure to the parasite, and most often a low intensity of infection, positive serology strongly suggests an active infection, even in the presence of negative stool and urine examinations.

Praziquantel is the treatment of choice with cure rates equal to or greater than 85%. Some side effects are directly drug-induced (vomiting, abdominal pain), while others are related to the host immune response to the dying parasites (abdominal pain, urticarial, diarrhea). Pregnant women and lactating women should be offered immediate treatment whenever the infection is diagnosed.

There are a number of different ways to prevent transmission: (1) reduction or elimination of intermediate host snails or snail habitats; (2) preventing human excreta from contaminating local water sources; (3) providing safe fresh water to reduce contact with snail-infested water sources; (4) distribution of protective footwear or clothing, or use of protective medicated salves to prevent cercariae from reaching the skin; (5) use of periodic drugs to limit infection intensity in exposed populations.

Strongyloides (*Strongyloides fuelleborni* and *Strongyloides stercoralis*):

Strongyloides identified during the stool analysis of IMO’s Rapid Appraisal in El Paraiso.

Estimates of the global prevalence of strongyloidiasis vary between 3 million and 100 million people infected, making it considerably less common than infections with other major intestinal nematodes. The semitransparent, colorless female worms measuring 2.2 mm in length embed themselves and deposit their eggs in the upper small intestine. Females lay eggs without the need for fertilization and hatch in the mucosa. Then, the noninfectious larvae work their way into the lumen of the bowel. If excreted with feces onto soil in a warm, humid environment, they develop into infective larvae that can penetrate human skin, migrate to the lungs, pass up to the trachea where they are swallowed, and eventually make their way back down into the GI tract. There they eventually mature into adult worms that produce eggs in the small intestine.

A crucial feature of *Strongyloides* that sets it apart from all other major parasitic worms is that non-infective larvae have the ability to develop into infective larvae within the bowel, reenter the host through the colonic mucosa or perianal skin, and complete their life cycle without ever leaving the host. This process of autoinfection explains how the parasite can increase without external reinfection, persist indefinitely in a single host, and be transmitted directly from one person to another during close physical contact. Its medical significance lies in its ability to produce overwhelming infection in immunocompromised hosts, a consequence of its unique ability to replicate and increase in numbers without leaving its host.

While more than half of chronically infected people are asymptomatic, acute infections of strongyloidiasis yield a localized, itchy, red, raised rash soon after larval penetration. Diarrhea and abdominal pain may develop just before the appearance of larvae in the stool. Adult worms and larvae traversing the upper small bowel mucosa may produce abdominal pain, nausea, diarrhea, and blood loss. With hyperinfection, defined as repeated reinfection with larvae produced by worms already in the body due to their ability to complete the life cycle within a single host, increased numbers of larvae are found in the intestines, lungs, central nervous system (CNS), kidneys, liver, and almost any other organ. Gastrointestinal manifestations are common and include abdominal pain, nausea, vomiting, diarrhea, ileus, and edema of the bowel, which can lead to intestinal obstruction. Ulceration of the mucosa may produce massive hemorrhage, inflammation, or bacterial sepsis. Larvae migrating beyond the gastrointestinal tract produce pneumonitis with cough, hemoptysis, and respiratory failure. CNS invasion may cause meningitis and brain abscesses, with larvae in the cerebrospinal fluid and tissue. When Gram-negative bacteria gain access to the bloodstream via migrating larvae, bacterial sepsis, meningitis, and pneumonia occur frequently.

Strongyloides is primarily transmitted through contact with soil contaminated with infected feces. In ordinary hygienic conditions, human-to-human transmission does not appear to occur. Appropriate methods of human fecal sanitation and sewage disposal as well as the use of shoes are of paramount importance. Thus, the infection can be prevented by implementing public health measures aimed at ensuring proper disposal and treatment of excrement and by avoiding skin contact with contaminated soil.

Tapeworm *(Taenia saginata* and *Taenia solium*):

It is thought that tapeworms first infected humans up to two million years ago, making taeniasis among the oldest recognized of all human infections. There are at least six types of tapeworm known to infect people, identified by the animal from which they come. Today, between 40 and 60 million people are infected with tapeworm.

Eating undercooked meat of animals infected with these flat, segmented parasites is the primary route of taeniasis' transmission. The ingested worm attaches to the upper jejunum causing an inflammatory reaction in the intestines. The adult tapeworms head, called a scolex, attaches to the small intestinal mucosa. Segments of the tapeworm, called proglottids, develop from the neck of the scolex, mature, and become filled with thousands of eggs that are passed into the environment with feces. These eggs are then ingested by animals through contaminated soil or water, hatch in their intestines, attach to intestinal cells, enter circulation, and are transported throughout the animal's body where the cycle can start again.

Taeniasis in humans can persist for many years and often do not cause symptoms. But taeniasis may also be associated with persistent, minor symptoms including nausea, weakness, diarrhea, abdominal pain, hunger or loss of appetite, fatigue, weight loss and vitamin and mineral deficiencies. The most frequent complaint in *T. saginata* (beef tapeworm) is the uncomfortable sensation of the proglottids spontaneously forcing their way out of the rectum.

In rare cases, tapeworms can lead to serious complications, including blocking the intestine. If pork tapeworm eggs are accidentally swallowed, they can migrate to other parts of the body and cause damage to the liver, eyes, heart, and brain. These infections can be life threatening.

The definitive diagnosis of tapeworm infections typically is by identification of eggs or proglottids filled with eggs in the stool. However, proglottids often emerge spontaneously from the anus and deposit eggs on the perianal and perineal region; thus, anal swabs such as the "scotch tape" method may also be diagnostic.

Treating tapeworm larvae infection is more complicated than treating an adult tapeworm infection. While the adult tapeworm stays in the gut, the larvae may settle in other parts of the body. The medication prescribed depends on the species of tapeworm involved and the site of the infection. These drugs target the adult tapeworm, not the eggs, so avoiding reinfection is highly important.

The most common treatment for tapeworm infection involves the oral medications Praziquantel, Albendazole, and Nitazoxanide that are toxic to the adult tapeworm. These medications destroy the scolex of the tapeworm, as failure to do so will result in regrowth of the entire tapeworm.

Post-treatment follow-up stool examination should be performed approximately one to three months after the course of medication. These medications, if procedures are followed properly, are 95% effective.

Whipworm *(Trichuris trichiura*):

An estimated 800 million worldwide are infected with the whipworm *Trichuris trichiura*, (primarily children living in poverty in the tropics and subtropics).

Adult worms measure approximately 4 cm in length and typically reside in the cecum and ascending colon. In heavy infections the lower colon and rectum may be involved. The thin whip-like anterior part of the parasite, or its head, is embedded in the epithelium of the colon. Each day the female worm produces 7000 to 20,000 barrel-shaped eggs measuring 50 × 20 μm, with a thick shell and a clear plug at each end. Eggs shed in the feces onto soil embryonate and become infective under optimal conditions of moisture and shade within 2 to 4 weeks. After the egg has been ingested, the larva emerges from the shell and penetrates the mucosa of the cecum. Adult worms begin to produce eggs within approximately 3 months; they live 1 to 3 years or longer.

Trichuriasis is found in humid tropical environments and in temperate zones during warm and humid months. It is

most common in poor rural communities and areas in which sanitary facilities are lacking. Most infected people harbor fewer than 20 worms, but a small proportion, usually children in the 5- to 15-year-old age group, harbor more than 200 worms.

The period from ingestion of eggs to the appearance of eggs in the stool is 60–90 days.

Most people have no symptoms. Children with chronic *Trichuris* colitis have chronic abdominal pain, diarrhea, iron deficiency anemia, growth retardation, and clubbing of the fingers. Tenesmus and frequent passage of stools containing large amounts of mucus and often blood can occur. Recurrent rectal prolapse is common (adult worms can been seen in the prolapsed mucosa). In moderate or heavy infections, growth retardation and impaired cognitive function can be seen.

Diagnosis is made by identifying the adult worms on the mucosa of the prolapsed rectum or at colonoscopy or by finding the lemon-shaped eggs in the stool. The level of egg output is high (approximately 200 eggs/g of feces per worm pair).

Single doses of Albendazole, Mebendazole, and Pyrantel pamoate cure less than 50% of people with whipworm infection, and the reduction in worm burden may be less than 60%. Three days of Albendazole (400 mg orally daily) or Mebendazole (100 mg twice daily) are more effective in light and moderate infections, but for heavy infections, courses of 5 to 7 days of Albendazole are indicated. The combination of Albendazole and Ivermectin taken once yields the highest rate of cure and a greater reduction in the intensity of the infection.

1.2 Symptoms of Infection and Impact on Health

The symptoms of STH are nonspecific and only become evident when the infection is particularly severe. The nonspecific symptoms include nausea, fatigue, weakness, abdominal pain, and loss of appetite. STH causes morbidity through various different mechanisms. Three of particular significance are listed below.

- **Anemia**. All human cells depend on oxygen for survival; therefore, a decrease in the number of red blood cells can result in feelings of weakness, fatigue, malaise, and poor concentration. In severe cases of anemia, the body increases cardiac output in an attempt to compensate for the lack of oxygen. This may lead to palpitations, angina, and even heart failure.
- **Intestinal Obstruction**. In cases of massive infection, a bolus of parasites can cause intestinal obstruction. Obstruction is usually partial but overtime, it can become complete. Additionally, obstruction can occur where parasites excrete neurotoxins that cause contractions of the small bowel. A lingering obstruction gets complicated with the probability of intussusception, volvulus, necrotic bowel, or perforation, all of which are life threatening.
- **Malnutrition**. Malnutrition becomes life threatening in association with STH as STHs feed on host tissues, including blood, leading to a loss of iron and protein. Additionally, STH impairs the body's ability to absorb or assimilate food, decreasing the absorption of essential nutrients. In particular, STHs compete for already low levels of vitamin A in the intestine of the host. Because vitamin A maintains the integrity of the epithelium in the respiratory and gastrointestinal tracts, its deficiency increases the risk of developing respiratory disease and chronic diarrhea. Malnutrition weakens every part of the immune system, which increases the risk of infection and infectious disease. Infectious diseases like malaria, measles, persistent diarrhea, and pneumonia can also keep the body from absorbing adequate food.

The impact of STH on an infected person's life can be significant. Some examples include:

- **Stunting**. Chronic malnutrition occurring over time interferes with a child's ability to develop and grow. Malnutrition and recurrent infections in combination with STH are major contributors to growth stunting. A stunted child may appear normal, but is significantly smaller and shorter than children who are adequately nourished. Their immune system is weaker, leaving them more vulnerable to disease and they are five times more likely to die from diarrhea. Once established, stunting and its effects typically become permanent. Stunted children may never regain the height lost as a result of stunting, and most children will never gain the corresponding body weight. It also leads to premature death later in life because vital organs never fully develop during childhood. Height-for-age, weight-for-age, and weight-for-height are frequently used indicators of nutritional status of children. Because these represent the long-term effects of malnutrition and are not sensitive to recent, short-term changes in dietary intake, height and weight are measured as part of the Rapid Appraisal.

- **Need for surgery**. When their numbers in the body become extremely high, STHs build up in the child's intestines causing obstruction, hindering normal function, and eventually blocking the intestine entirely. The only solution in this situation is an emergent surgical intervention that in most cases is not possible in remote areas, causing the child's premature death.
- **Reduced ability to learn**. In an already malnourished child, STHs further rob the body of the nutrients required for physical and mental development. In the formative years of a child's growth, this chronic malnutrition results in a significant and irreversible drop in IQ. Children with STH are therefore less able to concentrate or process information, compromising their formal education that is, in most cases, already limited.

1.3 Who is most at risk?

According to the World Health Organization (WHO), children are at risk as soon as they stop breastfeeding and start crawling on the ground, frequently putting their hands in their mouths. Without treatment and prevention, children are infected and repeatedly re-infected, causing the number of STHs they harbor to steadily increase. By the time they reach school, they can be harboring hundreds of STHs or more.

Preschool and primary school-age children should be targeted for treatment and prevention of STH for the following reasons:

- They typically have the highest burden of STH.
- They are more susceptible to other infections.
- They are at a critical time of their physical and mental development.
- Primary school is foundational for secondary and higher levels of learning.
- Decreased STH prevalence among this group reduces the level of contaminate in the environment.

1.4 Treatment

IMO's preferred anthelmintic is Albendazole. Not only is Albendazole effective, it is also:

- Safe for young children and pregnant women
- Easy to administer due to its standard dose regardless of weight
- Chewable
- Relatively inexpensive.

The recommended dose is Albendazole 400mg, once, every six months.

1.5 Prevention

WHO advocates administering anthelmintic medication at regular intervals to populations at risk. This approach may lower the prevalence and intensity of STH but is unlikely to eliminate transmission in the absence of sanitation, clean water supplies, and overall economic development. The improvement of infrastructure, sanitation standards such as properly washing and cooking food and hand washing, and environmental factors such as housing conditions and access to clean water are broad steps toward prevention of STH.

Regular mass treatment is a commonly accepted remedy of STH because of the ease with which controlled doses of safe, effective, and relatively inexpensive anthelmintic medication can be administered. However, a disturbing aspect of this widespread practice of annual or semi-annual deworming of children and other groups is the concern about resistance developing to Albendazole and other anthelmintics. Prevention is, therefore, paramount.

General Recommendations for STH Prevention

Regular treatment will only result in a short-term reduction of infection. Re-infection is inevitable within a short period of time unless key preventive interventions are undertaken. The interventions outlined below are the basic requirements necessary to break the cycle of transmission and thus eliminate STH as a public health problem.

Use Safe Water

- Establish and utilize a safe water system.
    - Protected natural spring
    - Engineered method
        - Borehole
        - Dug well
        - Public standpipe
    - Filtration
        - Ceramic
        - Slow sand
    - Rainwater collection
    - Solar Disinfection
    - Boiled water
    - Chlorination
- Safe Water Storage
    - Container must only be used to transport/store clean water
    - Container must be kept closed with a properly fitted lid
    - Containers should have a small opening or a tap for access to water
    - Do not insert hands or objects into the container
- Use safe water for all activities of life
    - Drinking
    - Cooking
    - Hand-washing
    - Bathing/personal hygiene
- Hydrate the body adequately to receive full health benefits
    - Drink only safe water
    - Drink water everyday
    - Recommended daily amount of water is as follows:
        - 5-8 years old—1 liter
        - 9-12 years old—1.5 liter
        - 13+ years old—2 liters
        - Women—2 liters
        - Men—3 liters
- Practice proper food preparation
    - Clean food preparation areas and allow to dry thoroughly
    - Wash vegetables and fruits thoroughly, especially when eating them raw
    - Cook food and vegetables properly

Practice Proper Hygiene

- Wash hands
    - When the hands are dirty
    - After using the toilet
    - Before meals/snacks
    - Before taking medication
    - Before and after feeding and caring for children
- Bathe and take care of the body
- Always use soap—it causes sticky particles to loosen from the skin
- Exercise oral hygiene
- Wear shoes when outside the home
    - Protective shoes when walking distances
    - Slipper-type shoe around the homestead

Manage Human Waste

- Discourage open defecation
- Properly dispose of human waste, especially children's stools
- Use toilets or latrines—one of the most effective measures to break the cycle of transmission
    - Train and encourage all family members to use toilets
    - Proper construction must include barrier between user and excreta
    - Keep toilets clean and well maintained
- Composting toilet
    - Safe and sanitary management of human feces
    - Decomposes the germs and recycles the nutrients from human waste
    - Does not require power or water
- Pit latrine
    - Creates breeding ground for flies
    - Can be dangerous if not properly constructed, maintained or protected
    - Difficult to clean
- Designate a special field for defecation away from homesteads, water source, and food storage
- Only when absolutely necessary:
    - Dig a hole in the ground for defecation
    - Cover the hole with soil afterward to avoid exposed excreta

Abide by a Treatment Schedule

- Take medication at regular intervals
- Go to health services to provide treatment of symptomatic illness

Distribute Health Education

- Anatomy and physiology
    - Teach general information about the body
    - Teach proper care and disease prevention
- Biology of the body — teach how the body functions in general
- Helminthiasis and its physiology within the body
    - How helminths enter the body
    - How helminths migrate throughout the body and eventually reside in the intestines
    - The effect of helminthiasis on the body
- Nutrition
    - Define and discuss a balanced, nutritional diet
    - Incorporate a nutritional diet within the cultural context
        - Identify available foods
        - Explore options to meet nutritional requirements

Adopt Healthful Habits

- Education and practice are the most important activities to motivate children to change their behavior.
- Children can be effective agents to convince parents, family members, and community members to change their behaviors.
- Schools are important in the training process
    - Lead by example—administrators and teachers should wash their hands at the appropriate times
    - Be consistent
        - Enforce healthy behavior all the time
        - Consistency causes habits to form
        - Habits become a way of life
    - Make it easy and practical for the children and teachers to wash
        - Set up a hand-washing area at the school
        - Have clean water and soap always available at the station
- Present teaching in a positive rather than a negative context.
    - “Clean hands feel good” instead of saying “Dirty hands cause disease”
    - Encourage the children to try new ways of doing things
    - Rewards good habits
- Encourage self-respect—mind, body, and spirit. Self-respect is evidenced by the following:
    - Proper care of your body
    - Maintain privacy
    - Practice modesty