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PREVALENCE AND ASSOCIATED RISK FACTORS OF SOIL-TRANSMITTED HELMINTHS INFECTIONS AMONG SCHOOL CHILDREN IN SELECTED FULL CYCLE PRIMARY SCHOOLS, AROUND LAKE TANA, ETHIOPIA

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ETHIOPIA

BY
MELSEW GETANEH BOGALE

JULY 2021
BAHIR DAR, ETHIOPIA

BAHIR DAR UNIVERSITY
COLLEGE OF SCIENCE
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CYCLE PRIMARY SCHOOLS, AROUND LAKE TANA,
ETHIOPIA**

A THESIS SUBMITTED TO COLLEGE OF SCIENCE,
DEPARTMENT OF BIOLOGY IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF MASTER OF
SCIENCE IN BIOLOGY (BIOMEDICAL SCIENCES)

BY

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JULY 2021

BAHIR DAR, ETHIOPIA

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Advisor's Approval Form

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I hereby certify that I have supervised, read, and evaluated this thesis/dissertation titled "Prevalence of soil-transmitted helminthic infections and their associated risk factors among schoolchildren in selected full-cycle primary schools around Lake Tana, Bahir Dar, Ethiopia" by Melsew Getaneh Bogale prepared under my guidance. I recommend the thesis/dissertation is submitted for oral defense.

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LIST OF ABBREVIATION AND ACRONYMS

AOR:	Adjusted odds ratio
CDC:	Center for Diseases Control
COR:	Crude odds ratio
EPG:	Eggs per Gram of Feces.
L1:	First stage Larva
L2:	Second stage Larva
L3:	Third stage Larva
MDA:	Mass Drug Administration
NTD:	Neglected Tropical Disease
PSAC:	Preschool-Age Children
RPM:	Revolution per Minute
SAC:	School-Age Children
SPSS:	Statistical Package for Social Science
SSA:	Sub-Sahara Africa
STHs:	Soil-Transmitted Helminths
WHO:	World Health Organization

ABSTRACT

Soil-transmitted helminthic infections are among the most common infections worldwide affecting the poorest and most deprived communities. The three major soil-transmitted helminths (STHs) are *Ascaris lumbricoides*, *Trichuris trichiura* and hookworm. This study was aimed to determine the prevalence of soil-transmitted helminthic infections and associated risk factors among schoolchildren in selected primary schools around Lake Tana, Bahir Dar, Ethiopia. A school based cross-sectional study was conducted from February 1, 2021 to May 12, 2021 G.C involving 337 study subjects. A systematic random sampling method was utilized to select the study participants from the selected schools. Data related to socio-demographic characteristics of the study participants and risk factors for STH infections were collected using a pretested questionnaire. Stool samples were collected in sterile plastic containers from each participant and processed using Ritchie's concentration and Kato-Katz thick fecal smear techniques at Bahir Dar University Biomedical Laboratory. The overall prevalence of STH infection was 38.3 % (129/337). Hookworm infection was the predominant STHs infection, which was detected in 88(26.1%) schoolchildren followed by *Ascaris lumbricoides* which infected 50 (14.8%) of the study subjects. *Trichiuris trichiura* was the least prevalent geo-helminthic infection and it was detected among five students (1.5%) only. Majority 115(34.1%) of the study subjects, had single infections. Double infection occurred in 14(4.2%) of study subjects. The sensitivity and specificity testing between the two methods, Ritchie's concentration techniques more preferable for Hookworm screening than *A.lumbricoides* and *T.trichiura* but Kato-Katz-technique was more effective for screening than Ritchie's concentration techniques for *A.lumbricoides* and *T.trichiura* detection. The common explanatory risk factors of STHs infection in the study subjects, among others, poor personal hygienic condition, less frequent shoes wearing habit, soil contact, occupation risk, and lack of hand washing habit before meal. Based on the result it could be concluded that STHs infection is a common problem among the schoolchildren around Lake Tana. Therefore, education on personal and environmental hygiene should be taken into account to reduce the prevalence of STHs infection. Moreover, schoolchildren and other risk group should receive regular deworming or treatment to control the transmission of STHs infections

Keywords: *Ascaris lumbricoides*, Ethiopia, Hookworm, Lake Tana, Schoolchildren, *Trichuris trichiura*

1. INTRODUCTION

1.1. Background of the Study

Helminths (worms) are multicellular organisms, normally visible to the naked eye in their adult stages (Tilahun Eyamo *et al.*, 2019). They have a flattened or elongated tube-like body, exhibiting bilateral symmetry (Tsega Teshale *et al.*, 2018). Most helminths are free-living organisms in aquatic and terrestrial environments where as others occur as parasites in humans, animals and some plants. Reproductive processes of helminths are diverse. The adults of helminths may be hermaphroditic (most flukes and tape worms) that means individuals with male and female reproductive systems or bisexual species (blood flukes and nematodes) have separate male and female adults, unlike other pathogens (viruses, bacteria, protozoa and fungi). Helminths do not proliferate within their hosts and have pre-adult stages (ova, larvae) which live externally or in other hosts (Karshima, 2018).

Helminths have three main developmental stages in their life-cycle: eggs, larvae and adults. The parasitic intestinal helminths can be divided into three groups which include the nematodes (roundworms), trematodes (flukes) and the cestodes (tapeworms). Representatives of each of these groups are important parasites for school age children. The adult worms, that inhabit the intestine, discharge their eggs or larvae in faeces (WHO, 2017).

Nematodes (round worms) have long thin unsegment tube-like body with anterior mouth and longitudinal digestive tract. They have a fluid-filled internal body cavity (pseudocoelom) which acts as a hydrostatic skeleton providing rigidity (so-called ‘tubes under pressure’). Nematodes are the most common helminths parasitizing humans (WHO, 2017). The parasitic nematodes are divided into intestinal and tissue and blood dwelling nematodes (Brandon-Mong *et al.*, 2017). In turn, intestinal nematodes are divided into two, intestinal nematodes with tissue stage such as *Ascaris lumbricoides*, Hookworms, *Strongyloides stercoralis* and intestinal nematodes without tissue stage such as *Enterobius vermicularis* and *Trichuris trichiura* (Yang *et al.*, 2018). Soil-transmitted helminthic (STH) infections are among the most prevalent and widespread chronic human infections worldwide (Silver *et al.*, 2018). The most common STHs are *A. lumbricoides*, *T.trichiura* and the hookworms, (*Necator americanus* and *Ancylostoma duodenale*). An estimated 5.3 billion infections occur worldwide, including 1.0 billion school

aged children, living in areas of stable transmission for at least one STH species. STH infections are the greatest public health burden occurring in developing countries, particularly in sub-Saharan Africa countries (Fikru Gashaw *et al.*, 2015). The majority of these infections result from low standard of living, poor socioeconomic status, poor personal and environmental hygiene sanitation (Silver *et al.*, 2018).

STH infections are widely distributed in tropical and sub-tropical areas, especially in poor populations of Ethiopia, among them the rural people who are living around Lake Tana are more vulnerable group to these infections. The prevalence and intensity of soil-transmitted helminthic infection is different among various communities; therefore, there is a need for periodical determination of the prevalence for future prevention and control program. There is no recent information about soil-transmitted helminthic infection and associated risk factors in the study area. Therefore, the aim of present study was to determine the prevalence and associated risk factors of soil-transmitted helminthic infections among schoolchildren in five selected full-cycle government schools around Lake Tana, Amhara regional state, Ethiopia.

1.2. Statements of the Problem

Soil-transmitted helminthic infection is a world-wide public health concern and the major cause of human disease, particularly in developing countries including Ethiopia (Getaneh Alemu *et al.*, 2018). Prevalence of STH infection remains higher in sub-Saharan Africa and vary within and between countries. School-age children who live around lakes are particularly susceptible to soil-transmitted helminthic infection (Fikreslasie Samuel *et al.*, 2017). Warm and moist environments favor for STH ova development (for example, these condition favor for hookworms' ova develop into larva stage (L3) that can penetrate by piercing human skin). In addition, helminths are one of the neglected tropical diseases that can be spread through contaminated water and food with soil. The livelihood of several thousand people depends on the Lake Tana. As the lake is used for different activities such as fishing, swimming and recreation purpose, the area around the lake is likely to be highly contaminated with human fecal matter and other wastes. In addition, the warm temperature and high humidity around the Lake Tana may create conducive conditions for the long term survival of the different stages of soil-transmitted helminthes (Fikreslasie Samuel *et al.*, 2017).

The burden and severity of these diseases will be higher in children due to their elevated susceptibility to the potential risk factors of STH infections and their weak body resistance to parasitic load than adults (Eprem Tefera *et al.*, 2017). Soil-transmitted helminthic infection is suggested to be not only associated with high illness and death of schoolchildren but also with poor school performance of them (Hossain and Bhuiyan, 2018).

Soil-transmitted helminthic infection is often associated with behavioral, environmental and socio economic factors (Hossain and Bhuiyan, 2018). Soil-transmitted helminths also cause impaired childhood growth and cognitive development and worse school performance (WHO, 2017). More than half of all deaths from communicable diseases that occur globally in school age -children from 5-15 years of age, and these groups are more vulnerable to soil-transmitted helminths (WHO, 2017).

There is a lack of recent and well documented information about prevalence of STHs and associated risk factors in the study area. Besides, the prevalence of STH infections vary extremely from place to place among the study areas. These variations in the prevalence of STH infection could be due to differences in distribution of associated factors in the study areas. The population density is high in the areas around Lake Tana. Lake Tana. Moreover, prevalence of STHs and associated risk factors are not addressed in the present study sites , Bahir Dar city (Robite primary school), North Achefer (Kunzila primary school), Woramite primary school, Saint Hana primary school and Gurer (Deki- island) primary school. Therefore, the aim of this study was to assess the prevalence of STHs infection and their associated risk factors among selected governmental school children located around Lake Tana.

1.3. Research Questions

1. What was the prevalence of soil-transmitted helminthic infections in the study area?
2. What were the common types of intestinal soil-transmitted helminths that infect school-age children in the study area?
3. What were the predisposing factors of soil-transmitted helminthic infections in the study area?
4. Which diagnostic method between Ritchie's Concentration and Kato-Katz has higher Performance for STHs detection?

1.4. Objectives

1.4.1. General Objective

- ❖ To determine the prevalence and associated risk factor of soil-transmitted helminthic infections among schoolchildren in selected full-cycle primary schools around Lake Tana, Amhara Regional State, Ethiopia.

1.4.2. Specific Objectives

1. To determine the prevalence of soil-transmitted helminthic infection among children attending in the selected governmental schools around Lake Tana, Ethiopia.
2. To identify the predominant soil-transmitted helminth that affect schoolchildren in the study area.
3. To identify the major explanatory risk factors associated with the prevalence of soil-transmitted helminthic infection among schoolchildren in and around Lake Tana.
4. To compare the performance of Ritchie's concentration and Kato-Katz diagnostic methods for STHs detections

1.5. Significance of the Study

This findings of the study hoped to provide a baseline information on prevalence and intensity of soil-transmitted helminthic infections among school-age children and factors associated with STH infection around Lake Tana. School-age children are the most important resource for future economic growth and development of any country. If they are at risk of these disease, the overall status of the country would be also at risk. Thus, school based research is crucial indicator for ongoing control and prevention strategies at regional and federal government. This study would be evaluating sex and age-related prevalence among school-age children. Finally, helminthic infections are governed by different factors such as behavioral, biological, environmental, socioeconomic and health system. The risk factors' identification in this study would be an important point for intervention in the study area. Thus, findings of this study might be essential in designing and implementing appropriate interventions to reduce the prevalence of parasitic helminthic infection among school-age children in the study area. In addition to this, the research would be a base line for further research.

2. LITERATURE REVIEWS

2.1. The Common Parasitic species of Soil transmitted Helminths

The three major soil transmitted helminths considered to be the global public health concern as *A. lumbricoides*, *T. trichuria* (whipe worm) and *A. duodenale* or *N. americanus* (hookworm). The soil-transmitted helminths are a group of parasitic nematode worms causing human infection through contact with parasite eggs or larvae that thrive in the warm and moist soil of the world's tropical and subtropical countries (Merem Abdie *et al.*, 2017).

As adult worms, the soil-transmitted helminths live for a years in the human gastrointestinal tract. More than a billion people are infected with at least one species of particular organisms see in (Table 2.1) (CDC, 2018). Roundworms (*A. lumbricoides*), whipworms (*T. trichiura*), and hookworms (*N. americanus* or *A. duodenale*) are the most common soil-transmitted helminths that infect humans and the latter two species are normally jointly reported as 'hookworm' because they are not distinguishable by microscope examination (Hossain and Bhuiyan, 2018). Other helminths that cause less man infection in the case of soil contaminated are *E. vermicularis* (pinworm), *S. stercoralis* (Cochin-china diarrhea). *E. vermicularis* and *T. trichiura* are exclusively intestinal parasites and other helminths listed above have both intestinal and tissue phases (Hossain and Bhuiyan, 2018). Before becoming adults in their human host, the larvae of *A. lumbricoides*, *S. stercoralis*, and hookworms have heart lung migration but not in *T. trichiura* (Lemma Workineh *et al.*, 2020).

Table 1: Characteristics of the major soil-transmitted helminths (CDC, 2018).

Species	Length (mm)	Daily egg output per female worm	Location in host	Lifespan (years)
<i>Ascaris lumbricoides</i>	150–400	200 000	Small intestine	1
<i>Trichuris trichiura</i>	30–50	3000–5000	Caecum and colon	1.5–2.0
<i>Necator americanus</i>	7-13	9000-10 000	Upper small intestine	5–7
<i>Hookworms</i> <i>Ancylostoma duodenale</i>	8–13	25 000–30 000	Small intestine	5–7

The soil-transmitted helminths are one of the world's most important causes of physical and intellectual growth retardation among school age-children and showed that helminthic infection remain among the major causes of children misery and death in the world today (Karshima, 2018). In warm, tropical environments, where STHs are endemic and where sanitation is inadequate, parasite eggs are excreted in the faeces of infected individuals and contaminate the soil (Bamlaku Tadege and Techalew Shimelis, 2017). Children's become infected through ingestion of eggs or larvae that are passed in the faeces of infected people. Several studies have been conducted on the prevalence and associated factors of STHs among school children in Ethiopia (Eyob Tekalegn *et al.*, 2019). But in many parts of the country at large and specifically in Amhara region still there is no epidemiological information on the prevalence of STHs among vulnerable groups like preschool-age children (PSAC) and school-age children (SAC) who have frequent contact with soil because of their soil-loving behavior and put their contaminated hands inside their mouth. Studies have also stressed the profound effect of soil-transmitted helminthic infection on school performance and attendance and future economic productivity (CDC, 2018). Soil-transmitted helminthiasis (STH) is a term referring to a cluster of parasitic diseases caused by nematode worms that are transmitted among humans through faecally contaminated soil (Getaneh Alemu *et al.*, 2018).

Prevalence of infection is therefore highest in areas where sanitation is inadequate and water supplies are unsafe (Masaku *et al.*, 2017). The distribution of parasitic helminthic infection see in (Table-2.2) depends on many factors such as low socio-economic status, poor sanitation and personal hygiene, lack of potable water, poverty, low literacy rate, lack of safe drinking water, poor hygiene, malnutrition and hot and humid tropical climate (Teha Shumbej *et al.*, 2015). By thesis reason in Ethiopia, parasitic helminthic infections are very common, that causes of mortality and morbidity and causing a series of public health problems such as malnutrition, anemia, and growth retardation as well as higher susceptibility to other infections. Recent estimates indicate that more than 614 million school-age children are in need of treatment against these parasites which stimulate the parasite infection (WHO, 2011)

Table 2: The Soil-transmitted Helminthic infections of School-age children (CDC, 2018).

Species of parasite	Disease	Globaly Infected (millions)	In Ethiopia infected millions	Geographic region	More vulnerable group
<i>A. lumbricoides</i>	Roundworm Infection	807-1221	26	Worldwide	SAC
<i>T. trichiura</i>	Whipworm infection	604–795	21	Worldwide	SAC
<i>N.americanus</i> and <i>A. Duodenale</i>	Hookworm infection	576–740	11	Worldwide	SAC

Key: SAC=School-age children

2.2. Risk Factors Associated with Soil-Transmitted Helminthic Infection

2.2.1. Behavior, Household Clustered, and Occupation of schoolchildren’s

The geographical distribution of STHs was influenced by various factors including external environmental conditions like soil, absence of sanitary facilities, unsafe waste disposal system, inadequacy and lack of safe water supply, types of toilet and human factors including age, sex, socio-economic status and occupation (Teklemariam Ergat and Abebe Demissie, 2019). The predisposing factor for soil-transmitted helminthic infection depends on many reasons including habit sucking finger or nail bite of the infected children and personal and environmental hygiene. Child hands washing before and after using toilet were associated with intestinal parasitic infections (Temam Ibrahim *et al.*, 2018). Children who did not wash their hands before eating were more likely to acquire soil transmitted helminthic infection than children who wash their hands before meal regularly. Soil-Transmitted Helminthes eggs or infective stage of larvae excreted through faces. Those stages survive in external environments for several days or Weekes and can infect a child through contaminated food and water (CDC, 2018).

Absence of toilet or types of toilet facility were significantly associated with soil transmitted helminthic infection. The filariform Larva of hookworm can penetrate skin; there for fewer shoes wearing habits had a significant prevalence of those parasites (CDC, 2018). Specific occupations

and behaviors influence the prevalence and intensity of soil-transmitted helminthic infections. Because of the high rates of hookworm infection among adults, occupation probably has a greater influence on hookworm epidemiology. Organization in agricultural exposures remains a common denominator for human hookworm infection (Hotez *et al.*, 2014).

2.2.2. Poverty, Sanitation, and Urbanization

Soil-transmitted helminths depend for transmission on environments contaminated with egg-carrying feces. Consequently, helminths are intimately associated with poverty, poor sanitation, and lack of clean water (Lemma Workineh *et al.*, 2020). Hygiene is largely a matter of behavior, which determined by social traditions, customs and culture. Active efforts are possible only with the proper mind-set and if there is a motivation to keep disease away (Anuar *et al.*, 2014). For modifying a life style and make, it conducive to prevention of infectious diseases current styles of living should be studied in relation to hygienic practice. Nowadays, programs for school water, sanitation and hygiene education are being carried out in more than 70 countries (Lemma Workineh *et al.*, 2020). In at least 30 countries, the program is scaling up and expanding nationwide with the support of UNICEF. The school sanitation and hygiene education program ranges in size from a few hundreds to tens of thousands. The provision of safe water and improved sanitation are essential for the control of helminthic infection (WHO, 2017).

2.2.3. Climate, Water, and Season

Adequate warmth and moisture are key features for each of the soil-transmitted helminths. *Ascaris* and *Trichuris* eggs are hardier than hookworm L3 and therefore survive drier climates better. Like other developing countries, school health activities in Ethiopia especially in the study area are not satisfactory. Due to these poor sanitary facilities in schools, the prevalence of soil-helminthic infection among Ethiopian schoolchildren in different places is very high (Temam Ibrahim *et al.*, 2018).

2.3. Roundworm (*A. lumbricoides*)

Ascaris is the largest of human intestinal parasitic nematodes. Mature male and female can grow from 15-30cm and 20-35cm in length respectively the reason that female worms are larger than the males. Both usually inhabits the jejunum were they feed on semi-digested food present in the host (WHO, 2011). They also secret anti-trypsin chemicals for accomplished of computing with

the host system for ingested proteins. Infection acquired through the ingestion of infective egg from faecally contaminated soil, food and water. Since the egg very sticky, they readily adhere to raw fruits and vegetables, which washed with contaminated water (Eshetu Molla and Hassen Mamo, 2018).

A. lumbricoides is a soil-transmitted helminthes that reported to infect at least one fourth of the world's children's. *A. lumbricoides* is a forceful parasite by this quality is due in part to the resistant nature of its eggs, which are capable of surviving a wide range of hot and cold temperatures, chemicals and other extreme conditions (Tilahun Alelign *et al.*, 2015). The eggs of *Ascaris* are one of the most resistant of the helminthes egg and can remain infective for year has embedded in the soil (Lemma Workineh *et al.*, 2020).

A.lumbricoides is one of the most common intestinal helminthic human parasites, infecting 1.2 billion people worldwide. This is due to the fertilization ability of female worms to produce large numbers of eggs that can characterize by being highly resistant to environmental conditions (Yang *et al.*, 2018). Acute *ascaris* infections cause about 60,000 deaths per year, mainly in children due to intestinal obstruction. An infection occurs to both male and female, but children are more susceptible to infection, especially between the ages of five and 15 years that play with soil. This mainly distributed in areas with warm, moist climates (WHO, 2017).

2.3.1. Morphology of *A. lumbricoides*

The average female worm measures 30 cm x 5mm and the male is smaller than female worm. Adult: color pinkish, cylindrical with tapering ends. Male size: about 15cm curved tail with two spicules and female: size 2-25cm, with a straight tail. The female has a lifespan of 1 years and is capable of producing 200 000 eggs per (Yang *et al.*, 2018).

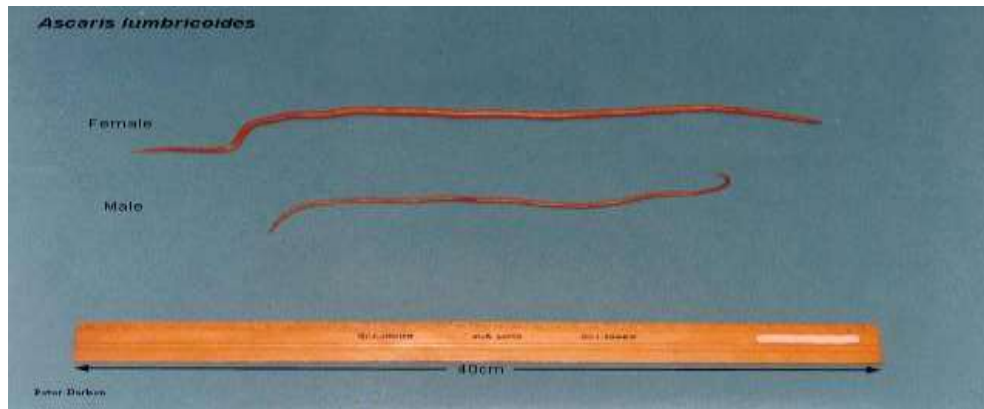


Figure 1: *A. lumbricoides* adult female and male (CDC, 2018).

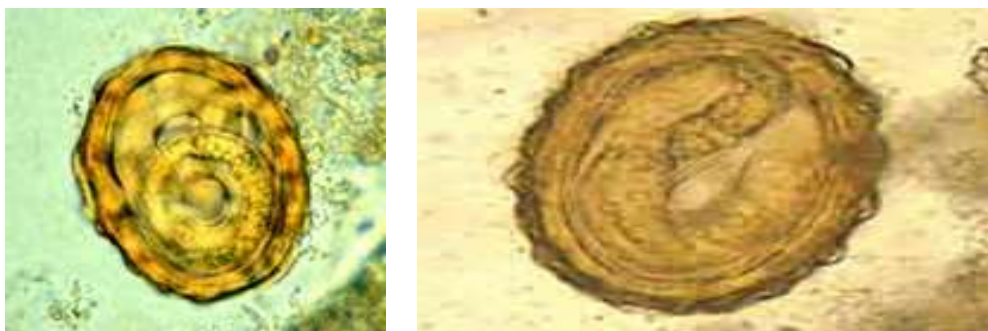


Figure 2: *Ascaris* egg containing a larva, which will be infective (CDC, 2018)

2.3.2. Epidemiology of *A. lumbricoides*

A. lumbricoides infects an estimated 807-1221 million people worldwide, most commonly pre-school-age children, school-age children and adolescents in endemic countries (WHO, 2017). The highest rates of *ascaris* infection occur in China, Southeast Asia, Africa, Coastal region of the west and Central Africa (Fikreslasie Samuel *et al.*, 2017). The prevalence of ascariasis in USA was less than 2% this was due to improved family income, maternal schooling, environmental sanitation and access health care (Anuar *et al.*, 2014). The widespread of human night soil as a major source of fertilizer in agricultural production was an important reason for high prevalence rates of ascariasis in china (Levecke *et al.*, 2014). The prevalence of STH infection tend to be low in much of the north Africa, probably because of the hot, dry climate conditions that overcome in much of the region are unsuitable for eggs and larvae (Hotez *et al.*, 2014).

Ethiopia has the second highest burden rank of ascariasis in sub-Saharan Africa: 26 million people infected in Ethiopia, which covers 15% of the overall burden in sub-Saharan Africa (CDC, 2018). Ascariasis can occur at all ages, but it was more prevalent in the 5 to 9 years age group. The incidence is higher in poor rural populations. In Ethiopia, ascariasis has highest rate in school age-children (2/3rd) and distributions of ascaris affected by altitude and climate was 29% in highlands, 35% in the temperate areas and 38% in the lowlands, then *ascaris* is second highest burden 26 million cases estimated (CDC, 2018.)

2.3.3. Transmission and Life Cycle of *A. lumbricoides*

Ascariasis can transmit primarily by fecal pollution of soil with infective stage egg containing second stage larva that penetrating skin of humans (Anuar *et al.*, 2014). The eating of soil by children putting their contaminated finger or toys with infective egg in to mouth and inhalation of eggs carried in air “Fecal-Soil-Oral Transmission” (CDC, 2018).

The adult *Ascaris* worms reside in the lumen of the small intestine where they feed on predigested food. Their life span ranges from 10 to 24 months. The adult worms can cover with a tough shell composed of collagens and lipids. This outer covering helps protect them from being digested by intestinal hydrolases. They also produce protease inhibitors that help to prevent digestion by the host. The adult female worm can produce 200,000 eggs per day. The eggs that pass out of the adult worm can fertilize, but not embrocated. Once the eggs exit the host via feces, embryo nation occurs in the soil and the embrocated eggs can subsequently ingested. There a mucopolysaccharide on the surface that promotes adhesion of the eggs to environmental surfaces (Staudacher *et al.*, 2014).

Within the embrocated egg, the first stage larva develops into the second stage larva. This second stage larva is stimulated to hatch by the presence of both the alkaline conditions in the small intestine and the solubilization of its outer layer by bile salts (Getaneh Alemu *et al.*, 2019). The hatched parasite that now resides in the lumen of the intestine penetrates the intestinal wall in addition, can carry to the liver through the portal circulation. It then travels via the blood stream to the heart and lungs by the pulmonary circulation (WHO, 2011).

The larva molts twice, enlarges and breaks into the alveoli of the lung. They then pass up through the bronchi and into the trachea, are swallowed and reach the small intestine once again see (Figure-2.3). Within the small intestine, the parasites molt twice more and mature into adult worms. The adult worms mate, although egg production may precede mating (Getaneh Alemu *et al.*, 2019). Adult worms live in the lumen of the small intestine. A female may produce approximately 200,000 eggs per day, which can pass with the feces. The female pass immature eggs which pass to the soil and mature in 2 weeks (WHO.,2011).

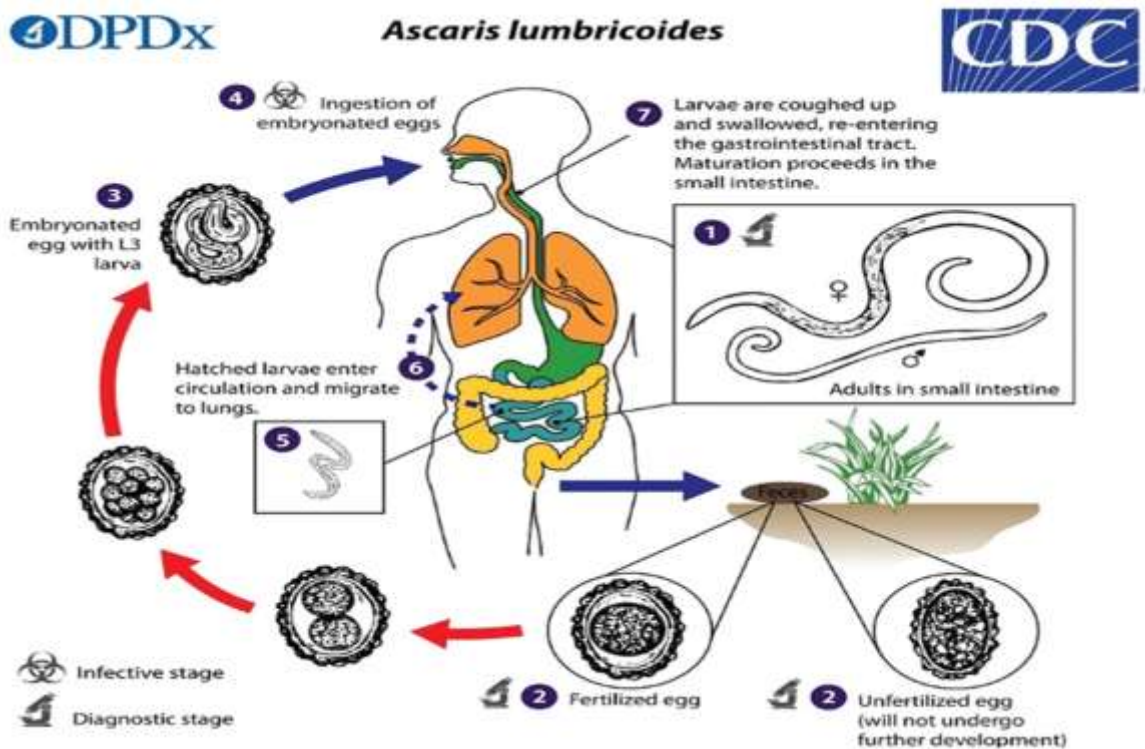


Figure 3: *Ascaris* life cycle (CDC, 2018)

2.3.4. Pathogenesis and Clinical Manifestations of Ascariasis

The first stages of infection are asymptomatic, especially when the number of present worms in the samples is tenuous. Moderate and chronic infections cause various symptoms, depending on which part of the body was, affected (Tilahun Eyamo *et al.*, 2019). For example, in the lungs, the migrating larvae cause cough, fever, and skin rashes for a few days. Most individuals infected with *A. lumbricoides* are essentially asymptomatic; the burden of symptomatic infection is relatively high because of the high prevalence of infection on children basis (Levecke *et al.*,

2014). Symptomatic disease usually related to both the larval migration stage and manifests as pulmonary disease, or to the intestinal stage of the adult worm (Pullan *et al.*, 2014).

Thus, symptoms more pronounced with higher burdens of migratory worms. Symptoms usually develop 9-12 days after ingestion of the eggs, while the larvae reside in the lung. Affected individuals often develop bronchospasm, dyspnea and wheezing. Fever, a persistent, nonproductive cough and, at times chest pain, can also occur. Hepatomegaly may also be present. Among the more serious complications of *Ascaris*, infection is intestinal obstruction (Hotez *et al.*, 2015). This occurs when a large number of worms are present in the small intestine and usually seen in children with heavy worm burdens. (Lemma Workineh *et al.*, 2020).

2.3.5. Diagnosis of Ascariasis

The diagnosis of ascariasis made through microscopic examination of stool specimens. *Ascaris* eggs easily recognized, although if very few eggs are present the diagnosis may easily missed. Finding and identification of eggs in the stool by Ritchie's concentration and Kato-Katz methods using adequately for detecting the presence or absent of *Ascaris* eggs in feces. The burden of eggs in stool determine by number WHO-guideline of light (1-4,999) EPG (egg of ascaris per gram of stool), moderate (5,000-49,999) EPG to heavy (>49,999) EPG of infections (Montresor *et al.*, 2002). Kato-Katz methods used to determine and interpret the intensity of worms' eggs in feces under a microscope by estimating EPG of stool. This way is the simplest and widely used in developing countries (Abebe Fenta *et al.*, 2020).

2.3.6. Treatment of ascariasis

Both albendazole and mebendazole are effective therapies for ascariasis. Mebendazole can prescribe as 100 mg BID for 3 days or 500 mg as a single dose (Junice *et al.*, 2014). The adverse effects of the drug include gastrointestinal symptoms, headache and rarely leukopenia. Albendazole prescribe, as a single dose of 400 mg. Albendazole's side effect profile is similar to mebendazole other alternative drug are piperazine citrate and pyrantel pamoate use (Getaneh Alemu *et al.*, 2019). "Mass Drug Administration" (MDA) reported up to 90% effective in treating the infection. These medications are all-active against the adult worm and are not active against larval stage (WHO, 2011).

2.3.7. Prevention of Ascariasis

The goal of recent helminthes control programs has been to recommend periodic mass treatment where the prevalence of infection in school-aged children greater than 50%. The current goal is to treat infected individual 2 to 3 times a year with either mebendazole or albendazole (Levecke *et al.*, 2014). Integrated control programs combining medical treatment with improvements in sanitation and health education need for effective long-term control. The evaluation of the efficacy, effectiveness' and the disease elimination of interventions as well as control in the community and in endemic areas strongly depend on the accuracy of the diagnostic tools, which define by their sensitivity and specificity (Levecke *et al.*, 2014).

2.4. *Trichuris trichuria* (Whipworm)

T.trichuria are nematodes belonging to the genus *Trichuris* called whipworms because their typical shape is threadlike along their anterior end that forms about two thirds of the body length while the posterior one third is abruptly thick (Lemma Workineh *et al.*, 2020). They are all parasites of the mammalian gut infecting humans worldwide especially in areas where the climate is warm and humid; sanitation standard is poor and characterized by massive environmental contamination with human faces. Adult male *T. trichiura* measures from 30 to 45 mm while the female measures 30 to 50 mm in length (Lemma Workineh *et al.*, 2020).

The *T.trichiura* “whipworm” is very common, but fortunately usually harmless. It lives in the cecum and rectum causing mild dysentery and anemia. In severe cases, it may lead to rectal prolapse and colonic trichuriasis (Staudacher *et al.*, 2014). Also known as, whipworm due to its characteristic shape, *Trichuris* can classified as a soil-transmitted helminthes because its life cycle mandates embryonic development of its eggs or larvae in the soil Getaneh Alemu *et al.*, 2019).

Trichuriasis or whipworm infection caused by *T. trichiura*. Human are the primary host for infection caused by *T. trichiura* but the species has detected in some non-human primates (Yang *et al.*, 2018). The mature male and female whipworms inhabit the transverse and ascending colons where they embed there narrow anterior portion in the host’s epithelium cells to obtain nutrients. The adult female deposit its egg from 3000-5000 eggs per day. Fertilized eggs deposits with the faeces are undeveloped and must embryonate before they can become infective (Lemma

Workineh *et al.*, 2020). The duration of egg maturation is approximately 18-25 days. Infections with *T. trichiura* occur via the oral fecal route caused by the ingestion of infective eggs from contaminated food hands; water and soil (Getaneh Alemu *et al.*, 2019).

2.4.1. Morphology of *T. trichiura*

The pinkish gray adult worm is approximately 30-50 mm in length, with the female generally being slightly larger than the male. The female organism is 50 mm long with a slender anterior (100-micrometer diameter) and a thicker (500 micrometers diameter) posterior end. The male is smaller and has a coiled posterior end. The *Trichuris* eggs are lemon or footballs shaped and have terminal plugs at both ends. The diagnostic characteristics are a typical barrel shape two polar plugs, which are unstained size: 50-54 μm by 22-23 μm . The external layer of the shell of the egg is yellow-brown (in contrast to the clear polar plugs) (CDC, 2013).



Figure 4: Adult Female and Male *T. trichiura* (CDC, 2013)



Figure 5: Eggs of *T. trichiura* (CDC, 2013)

2.4.2. Epidemiology of *T. trichiura*

Trichuriasis is a tropical disease of children (most common 5 to 15 yrs.). About 604 to 795 million people can be infected with *T. trichiura* globally, mainly in the tropical and subtropical regions: 21 million people infected in Ethiopia. Among these infected people 90% of infection in school age children found in Ethiopia (CDC, 2016). It is more prevalent in moist and warm regions than in arid and temperate countries and in rural than in urban areas. It is concentrated in families and groups with poorer sanitary habits. In many endemic communities, prevalence may be in excess of 80% (WHO, 2012). Infection starts early in life and reaches a peak among the age group five to 15 years (school age- children) after which it falls slightly (Hotez *et al.*, 2014).

It is the second most common nematode found in humans, behind *Ascaris*. Trichuriasis is more common in areas with tropical weather such as Asia, sub-Saharan Africa and the Americas, particularly in impoverished regions of the Ethiopia (Tilahun Eyamo *et al.*, 2019).. It is also more common in poor rural communities and areas that lack proper sanitary facilities with easily contaminated food, water and soil (CDC, 2016).

2.4.3. Transmission and Life Cycle of *T. trichiura*

Transmission occurs when contaminated soil reaches the food, water, or hands of a person and subsequently ingested (CDC, 2013). Adult female worms shed from 3,000 to 20,000 eggs per day, which are passed with the stool. In the soil, the eggs develop into a 2-cell stage, an advanced cleavage stage and then embryonate. The embryonated egg is actually infectious. Environmental factors such as high humidity and warm temperature quicken the development of the embryo (Tilahun Eyamo *et al.*, 2019).

This helps explain the geographic tendency for tropical environments. Under optimal conditions, embryonic development occurs between 15-30 days. Infection begins when these embryonated eggs are ingested. The eggs first hatch in the small intestine and release larvae that penetrate the columnar epithelium and situate themselves just above the lamina propria (Tilahun Eyamo *et al.*, 2019). After four molts, an immature adult emerges and passively migrates to the large intestine. Here, it inserts itself into the colonic columnar cells, usually in the cecum and ascending colon. Heavier burdens of infection spread to the transverse colon and rectum. Maturation and mating

occur here as well. Unlike *Ascaris* and hookworm, there is no migratory phase through the lung (Getaneh Alemu *et al.*, 2019).

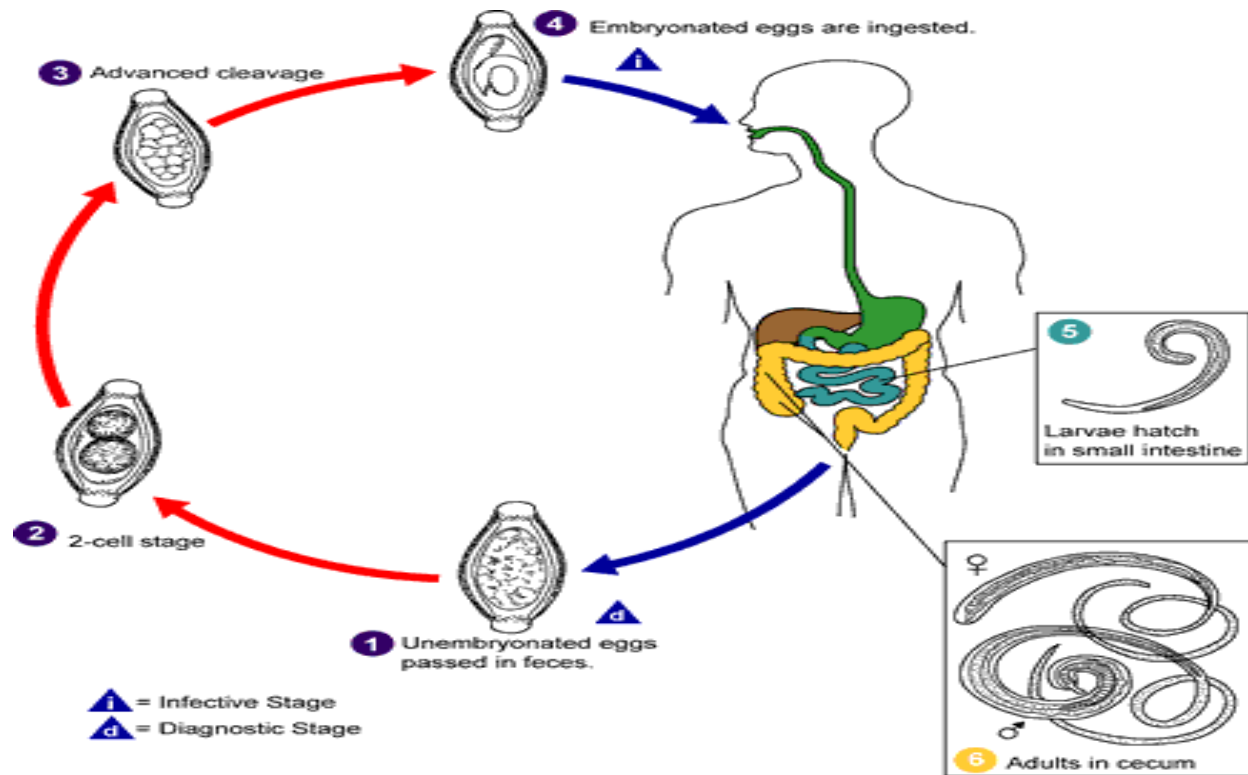


Figure 6: The Life Cycle of *T. trichiura* (CDC, 2016).

The unembryonated eggs are passed with the stool (1). In the soil, the eggs develop into a 2-cell stage (2), an advanced cleavage stage (3), and then they embryonate (4); eggs become infective in 15 to 30 days. After ingestion (soil-contaminated hands or food), the eggs hatch in the small intestine, and release larvae (5) that mature and establish themselves as adults in the colon (6). The adult worms (approximately 4 cm in length) live in the caecum and ascending colon. The females begin to oviposit 60 to 70 days after infection. Female worms in the caecum shed between 3,000 and 20,000 eggs per day. The life span of the adults is about 1 year (CDC, 2016).

2.4.4. Pathogenesis and Clinical Manifestations of trichuriasis

Symptoms can be determined largely by the worm burden: less than 10 worms are asymptomatic. Heavier infections (e.g., massive infantile trichuriasis) can be characterized by chronic profuse mucus and bloody diarrhea with abdominal pains and edematous prolapsed rectum. The infection

may result in malnutrition, weight loss and anemia and sometimes death. Frequently, infection with *Trichuris* is asymptomatic or results only in peripheral eosinophilia (CDC, 2016).

Clinical disease most often occurs in children, as they are tends to be most heavily infected and presents as Trichuris colitis. In fact, this is the most common and major disease entity associated with infection (Temam Ibrahim *et al.*, 2018). Acutely, some patients will develop Trichuris dysentery syndrome, characterized by abdominal pain and diarrhea with blood and mucus. Which are severe dysentery, children is develop weight loss and become emaciated. Anemia is common and results from both mucosal bleeding secondary to capillary damage and chronic inflammation. The anemia of trichuriasis is not as severe as that seen with hookworm (Getaneh Alemu *et al.*, 2019).

2.4.5. Diagnosis of trichuriasis

Infection can diagnose by microscopic identification of *Trichuris* eggs in feces. The eggs are quite characteristic, with a barrel or lemon shape, thick shell and a clear plug at each end. Finding and identification of eggs in the stool by Ritchie's concentration and Kato-Katz methods using adequately for detecting the presence or absent of *Trichuris* eggs in feces. The burden of eggs in stool determine by number WHO-guideline of light (1-999) EPG (egg of per gram of stool), moderate (1,000-9,999) EPG to heavy (>9,999) EPG of infections (Montresor *et al.*, 2002). Kato-Katz methods used to determine and interpret the intensity of worms' eggs in feces under a microscope by estimating EPG of stool. However, Ritchie's concentration procedures can recommend in light infections and kato-katz techniques for heavy Trichuriasis infection. Trichuriasis can also diagnosed by identifying the worm itself on the mucosa of a prolapsed rectum or during colonoscopy. Charcot- Leyden crystals in the stool in the absence of eggs in the stool should lead to further stool examinations for *T. trichuria* (Abebe Fenta *et al.*, 2020).

2.4.6. Treatment of trichuriasis

Mebendazole are the drugs of choice in treating trichuriasis. Mebendazole, 200 mg, for adults and 100 mg BID for children, for 3 days is effective or 500 mg as a single dose. Their anthelmintic activity is primarily due to their ability to inhibit microtubule polymerization by binding to beta-tubulin, a protein unique to invertebrates (Temam Ibrahim *et al.*, 2018). A single dose of albendazole has suggests for treatment; however, despite the appeal of adequate single

dose therapy, clinical studies have shown a cure rate of less than 25 percent. Longer duration of therapy, resulting in higher cure rates, can recommend for heavier burdens of infection (Merem Abdi *et al.*, 2017).

2.4.7. Prevention and Prophylaxis of trichuriasis

Drinking clean water, properly cleaning and cooking food, hand washing and wearing shoes are the most effective means of preventing soil-transmitted helminthic infections (Levecke *et al.*, 2014). Adequately sanitizing areas in which trichuriasis is prevalent is extremely problematic; these communities often lack the resources needed for such a substantial undertaking. Direct exposure to sunlight for greater than 12 hours or temperatures exceeding 40°C in excess of 1 hour kills the embryo within the egg, but under optimal conditions of moisture and shade in the warm tropical and subtropical soil, *Trichuris* eggs can remain viable for months (Merem Abdi *et al.*, 2017).

WHO recommends periodic treatment of school-aged children, by “Mass Drug Administering” (MDA) to populations at risk and the goal of therapy is to maintain the individual worm burden at a level less than that needed to cause significant morbidity or mortality. This strategy can use successfully in preventing and reversing malnutrition, iron-deficiency anemia, stunted growth and poor school performance (WHO, 2016).

2.5. Hookworm

Human hookworm infection was a soil-transmitted helminthic infection caused primarily by the nematode parasites *N. americanus* “New World” and *A. Duodenale* “Old World” Hookworm (Berhanu Elfu, 2018). The two species of hookworm *N. americanus* and *A. Duodenale* are found exclusively in human. It was one of the most important parasitic infections worldwide, ranking second only to malaria in terms of its impact on child and maternal health (Fikreslasie Samuel *et al.*, 2017).

The greatest concern from infection is blood loss. Aided by an organic anticoagulant a hookworm consumes about 0.25ml of host blood per day. Humans is considered the only major definitive host for these two parasites and there are no intermediate or reservoir hosts; in addition, hookworms do not reproduce within the host. After mating in the host intestinal tract,

each female adult worm produces thousands of eggs per day which then exit the body in feces (Temam Ibrahim *et al.*, 2018). *A. duodenale* female worms lay approximately 28,000 eggs daily, while the output from *N. americanus* worms was considerably less, averaging around 10,000 eggs a day (Fikreslasie Samuel *et al.*, 2017).

2.5.1. Morphology of Hookworms

Adult female hookworms are about 11 mm x 50 micrometers. Males are smaller. The anterior end of *N. americanus* is armed with a pair of curved cutting plates whereas *A. duodenale* is equipped with one or more pairs of teeth (Berhanu Elfu, 2018). Hookworm eggs are 60 micrometers x 35 micrometers. Hookworm eggs examined with Ritchie's concentration and Kato-Katz methods (eggs of *A. duodenale* and *N. Americanus* cannot be distinguished morphologically). They look like an odd piece of thread and are about 1 cm. They are white or light pinkish when living. The male's posterior end is expanded to form a copulatory bursa (Temam Ibrahim *et al.*, 2018).

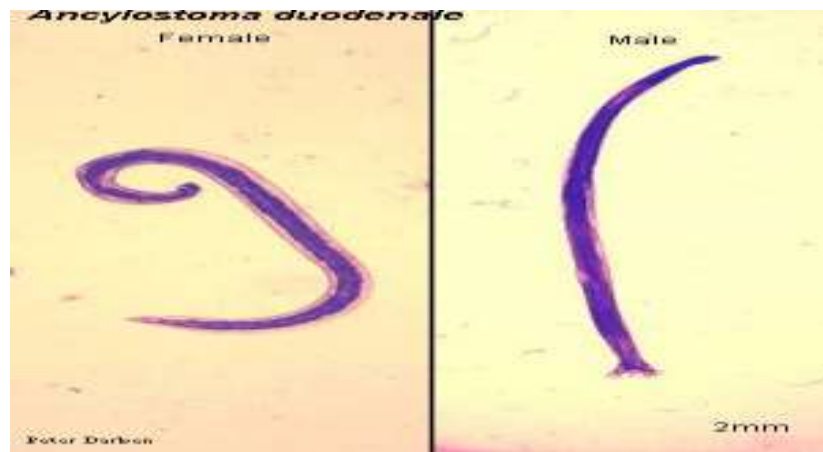


Figure 7: Morphology of *A. duodenale* adult hookworm (CDC, 2013).



Figure 8: Filariform larva and eggs of hookworm (CDC, 2013).

2.5.2. Epidemiology of Hookworm

Human hookworm infections were widely distributed throughout the tropics and sub-tropics country . *N. Americanus* (New world Hookworm) was the most prevalent hookworm worldwide, with the highest rates of infection in sub-Saharan Africa, the tropical regions of the Americas, south China and southeast Asia, whereas *A. duodenale* (Old world Hookworm) was more focally endemic in parts of India, China, sub-Saharan Africa, North Africa and a few regions of the Americas (WHO, 2015).

A. duodenale and *N. americanus* (hookworm) infect an estimated 576-740 million people. In contrast to *A.lumbricoides* and *T. trichiura*, the prevalence and intensity of hookworm infection is highest in adults, although children are also commonly infected (Temam Ibrahim *et al.*, 2018). *N. americanus* is the most widely distributed hookworm species, found across sub-Saharan Africa, the Americas and Asia, whereas *A. duodenale* found more locally. Both species may also co-exist in the same area and within the same individuals (Berhanu Elfu, 2018).

In Ethiopia, it estimated that there are 11 million people infected with hookworm. Which makes the country to have the third highest burden rank in sub-Saharan Africa. According to the study conducted in different areas of Ethiopia the prevalence of hookworm among school age children was 22% in Northwestern Ethiopia. *N. americanus* is the most widespread hookworm globally, whereas *A. duodenal* is more geographically restricted in distribution(Berhanu Elfu, 2018).

The adults are found in the small intestines of man. Both of the species are found in Ethiopia, but *N. americanus* are more common than *A. duodenale* highest infection rates in Ilubabor, Kefa and Welega. *A. duodonale* is associated with areas of poor soil coverage and high rate of drainage but *N. americanus* is found in red soil areas on flat plain (Temam Ibrahim *et al.*, 2018).

Hook worm infection is absent in low ,hot dry areas of Ethiopia and above 2500m. Climate is an important determinant factors for hookworm transmission, with adequate moisture and warm temperature essential for larval development in the soil. An equally important determinant of infection is poverty and the associated lack of sanitation and supply of clean water (WHO,2015). Among school children dwelling along the coastline of the Lake Hawassa the prevalence of hookworm was 7.7% (Bamlaku Tadege and Techalew Shimelis, 2017). On the other study done

in Arbaminch Zuria district the prevalence of hookworm was 14.5% (Getaneh Alemu *et al.*, 2018) and the study done in Yirgacheffee, Southern Ethiopia the prevalence was 16.7% (Eshetu Molla and Hassen Mamo, 2018). The prevalence of hookworm among elementary school children in ambo town, western Ethiopia was also 2.8% (Fikreslasie Samuel *et al.*, 2017). For example, studies in Africa and Asia show that between one-third and one-half of moderate and severe anemia's among both preschool and primary school-aged children. (Berhanu Elfu, 2018).

2.5.3. Transmission and Life Cycle of Hookworms

The life cycle of the hookworm is relatively simple: eggs expelled in the feces hatch, resulting in first-stage larvae (L1), which then molt to become second stage (L2), followed by third-stage (L3) larvae (Temam Ibrahim *et al.*, 2018). The L3 is the filariform stage of the parasite that is the non-feeding infective form larvae. The L3 is the infective stage and can actively penetrate the skin of a wide range of mammalian hosts. The larvae then enter the bloodstream, migrate through heart to the lungs, break through the alveoli, move up the trachea and are swallowed, eventually residing in the small intestine as immature adult worms (Figure 2.10). In the gut, the maturing, dioeciously, adult worms ingest blood by rupturing mucosal capillaries.

Hookworm transmission occurs when third-stage infective filariform larvae come into contact with skin. Hookworm larvae have the ability to actively penetrate the cutaneous tissues, most often those of the hands, feet, arms and legs due to exposure and usually through hair follicles or abraded skin. Following skin penetration, the larvae enter subcutaneous venues and lymphatics to gain access to the hosts afferent circulation. ultimately, they enter the pulmonary capillaries where they penetrate into the alveolar spaces, ascend the brachial tree to the trachea, traverse the epiglottis into the pharynx and are swallowed into the gastrointestinal tract. Larvae undergo two molts in the lumen of the intestine before developing into egg-laying adults approximately five to nine weeks after skin penetration (Silver *et al.*, 2018).

Adult hookworms attach onto the mucosa of the small intestine by means of cutting teeth in the case of *A. duodenale* or a rounded cutting plate in the case of *N. americanus* (Pullan *et al.*, 2014). After attachment, digestive enzymes are secreted that enable the parasite to burrow into the tissues of the sub mucosa where they derive nourishment from eating villous tissue and sucking blood into their digestive tracts. Hemoglobinasases within the hookworm digestive canal enable

digestion of human hemoglobin, which is a primary nutrient source of the parasite (Silver *et al.*, 2018).

Eggs are passed in the stool (1), and under favorable conditions (moisture, warmth, shade soil), larvae hatch in 1 to 2 days. The released rhabditiform larvae grow in the feces and/or the soil (2), and after 5 to 10 days (and two molts) they become filariform (third-stage) larvae that are infective (3). These infective larvae can survive 3 to 4 weeks in favorable environmental conditions. On contact with the human host, the larvae penetrate the skin and are carried through the veins to the heart and then to the lungs (Temam Ibrahim *et al.*, 2018). They penetrate into the pulmonary alveoli, ascend the bronchial tree to the pharynx, and is swallowed (4). The larvae reach the small intestine, where they reside and mature into adults. Adult worms live in the lumen of the small intestine, where they attach to the intestinal wall with resultant blood loss from the host (5) (Tilahun Eyamo *et al.*, 2019).



Figure 9: Vesicular skin eruption by cutaneous hookworm L₃larvae (Hossain and Bhuiyan, 2016)

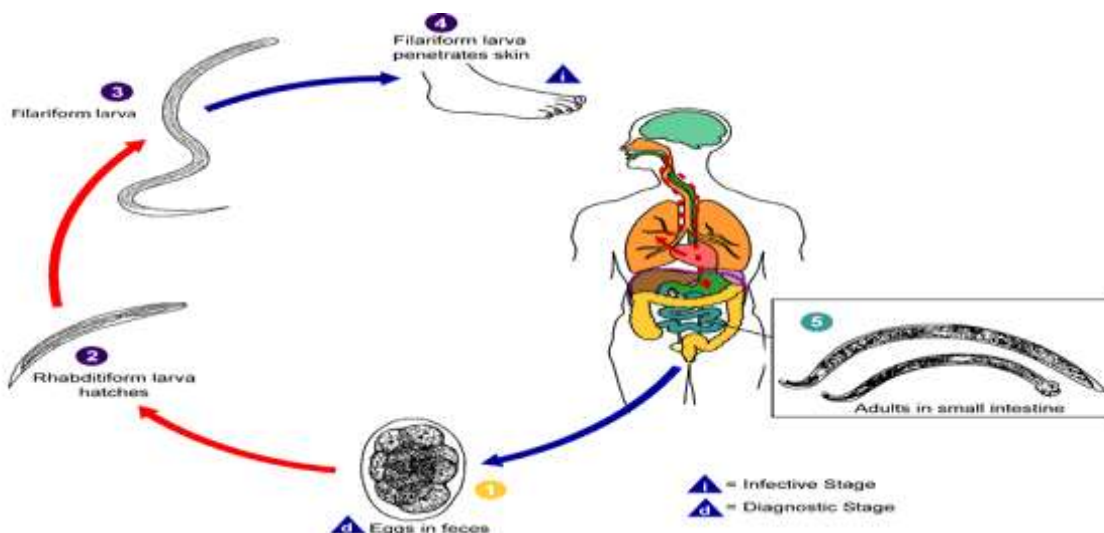


Figure 10: Life Cycle of Hookworms (CDC, 2013).

Most adult worms are eliminated in 1 to 2 years, but longevity records can reach several years. Some *A. duodenale* larvae, following penetration of the host skin, can become dormant (in the intestine or muscle) (Hotez *et al.*, 2015).

2.5.4. Pathogenesis and Clinical Manifestations of hookworm

The clinical features of hookworm infection can be separated into the acute manifestations associated with larval migration through the skin and other tissues and the acute and chronic manifestations resulting from parasitism of the gastrointestinal tract by adult worms. Migrating hookworm larvae irritate reactions in many of the tissues through which they pass, including several cutaneous syndromes that result from skin-penetrating larvae (Silver *et al.*, 2018).

Repeated exposure to *N. Americanu's* and *A. duodenale* filariform larvae can result in a hypersensitivity reaction known as “ground itch” , a pruritic local erythematous and popular rash that appears most commonly on the hands and feet (Janice *et al.*, 2014).The pulmonary symptoms are more pronounced and of longer duration with *A. duodenale* than with *N. americanus* infection (Masaku *et al.*, 2017). Acute symptomatic disease may also result from oral ingestion of *A. duodenale* larvae, referred to as the Wakana syndrome, which is characterized by nausea, vomiting, pharyngeal irritation, cough, dyspnea and hoarseness. Chronic hookworm disease occurs when the blood loss due to infection exceeds the nutritional reserves of the host, thus resulting in iron-deficiency anemia (Silver *et al.*, 2018).

The anemia and protein malnutrition that results from chronic intestinal parasitism cause long-term impairments in childhood physical, intellectual and cognitive development. Overwhelming hookworm infection may cause listlessness, coma and even death, especially in infants under one year of age (Temam Ibrahim *et al.*, 2018).For the reason that children reduced iron reserves; they are considered populations that are at particular risk for hookworm disease. Reported clinical features of this syndrome include abdominal pain, diarrhea, abdominal bloating, weight loss and rectal bleeding in children (Yang *et al.*, 2018).

2.5.5. Diagnosis of hookworm

Diagnosis of established hookworm infections is made primarily by means of microscopic identification of characteristic eggs in the stool. Finding and identification of eggs in the stool by

Ritchie's concentration and Kato-Katz methods using adequately for detecting the presence or absent of hookworm eggs in feces. The burden of eggs in stool determine by number WHO-guideline of light (1-1,999) EPG (eggs per gram of stool), moderate (2,000-3,999) EPG to heavy (>3,999) EPG of infections. Kato-Katz methods used to determine and interpret the intensity of worms' eggs in fesces under a microscope by estimating EPG of stool. (Abebe Fenta *et al.*, 2020). Although examination of the eggs cannot distinguish between *N. americanus* and *A. duodenale*, this is not clinically relevant. Differentiation between the two species can be made by either rearing filariform larvae from a fecal sample smeared on a moist filter paper strip for five to seven days (Montresor *et al.*, 2002).

2.5.6. Treatment of hookworm infection

The goal of treatment for *N. americanus* and *A. duodenale* infections is to eliminate adult worms from the gastrointestinal tract (Janice *et al.*, 2014). The most common drugs used for the treatment of hookworm infections worldwide are members of the benzimidazole anthelmintic class of drugs, of which mebendazole and albendazole are the two principle members. Mebendazole, 200 mg, for adults and 100 mg for children, for 3 days is effective. Sanitation is the chief method of control and sanitary disposal of fecal material and avoidance of contact with infected fecal material/soil (Tilahun Eyamo *et al.*, 2019).

2.5.7. Prevention and Control of hookworm

Hookworm infection removal or eradication from poor areas is difficult because of its transmission potentiality. The interruption of transmission cycle is another key components of STH specially hookworm control (Staudacher *et al.*, 2014). The current strategy to control hookworm is chemotherapy and support of health education, improved water quality, sanitation and socio-economic status. Beyond saying Proper personal and environmental hygiene and sanitation is corner stone for control of hookworm infection (Temam Ibrahim *et al.*, 2018).

Annual Mass Drug administration of benzimidazoles to school-aged children reduces and maintains the adult worm burden below the threshold associated with disease. The benefits of regular deworming in this age group include improvements in iron stores, growth and physical fitness, cognitive performance and school attendance (Tilahun Eyamo *et al.*, 2019).

3. MATERIALS AND METHODS

3.1. Description of Study Area

The study was conducted in five selected full-cycle primary schools in and around Lake Tana, northwestern Ethiopia, namely Robite , Kunzila , Woramit, Gurer and Saint Hana primary schools. Robite primary school found in Bahir Dar City administration and it is about 14 km from Bahir Dar city. It is located at 11°41' latitude N and 37°27'longitude E in northern part of Bahir Dar city with an elevation of 1845 meters above sea level (masl). Kunzila primary school is found in North Achefer woreda and it is about 58 km from Bahir Dar city. It is located at 11°52'latitude N and 37°01'longitude E in western part of Bahir Dar city with an elevation of 1805 masl. Woramit primary school is found in Bahir Dar City administration and it is about 7 km from Bahir Dar city. It is located at 11°36' latitude N and 37°20'longitude E in western part of Bahir Dar city with an elevation of 1798 masl. Saint Hana is found in South Gondar administrative Zone and it is about 50 km from Bahir Dar city. It is located at 11°53' latitude N and 37°35'longitude E in northern part of Bahir Dar city with an elevation of 1794 masl. Gurer primary school is found in Dek- Island, which is found in Bahir Dar Zuria woreda. The school is about 92 km from Bahir Dar city. The area is located at 11°53' latitude N and 37°14'longitude E in north-western part of the country with an elevation of 1790 masl in the Lake Tana .

Lake Tana is the largest lake by surface area of (3156km²) in Ethiopia, covering about 50% of total fresh water in Ethiopia and it is located about 570 kilometers away from Addis Ababa (Bahir Dar City Administration Office, General information about the Lake Tana , unpublished). Lake Tana is a shallow lake with a mean depth of 8m and maximum depth of 14m. Seven large permanent rivers and about 40 small seasonal rivers feed the lake. The lake has warm temperature climate and mean annual temperature of 13.5-27.7°C, the mean annual rainfall is about 1500mm. The summers here have a good deal of rainfall, while the winters have very little rain. In Bahir Dar, the average annual temperature is 20.4°C. The peak amount of rainfall occurs in June and July.

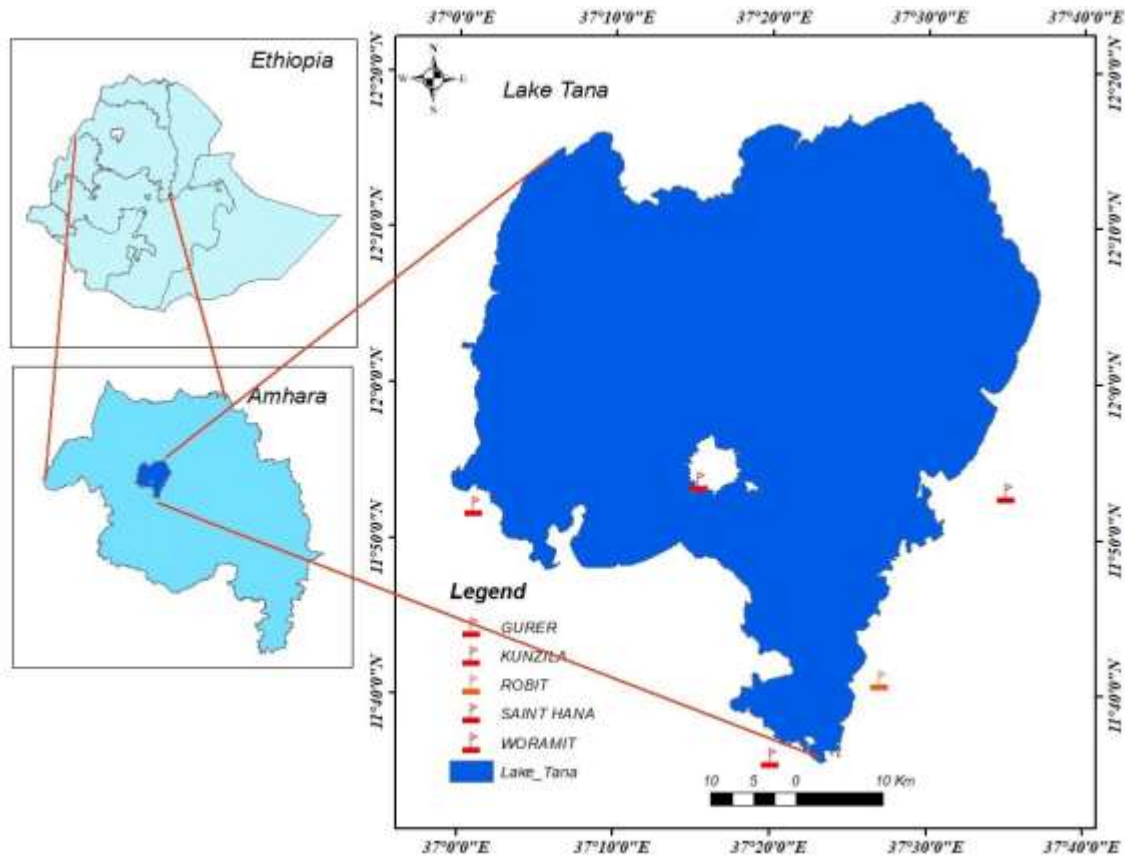


Figure 11: Map of the Study Area

3.2. Study Design

A school based cross-sectional study was conducted from February 1, 2021 to May 12, 2021 G.C to assess the prevalence of soil-transmitted helminthic infections and their associated risk factors among students who attended the selected primary schools around Lake Tana, northwest Ethiopia.

3.3. Source and Study Population

3.3.1. Source of Population

All students attending in five full-cycle primary schools (Robit, Kunzila, Woramit, Saint Hana and Gurer) were considered as source population. The total number of students attending during 2020/21 academic year in these schools were 4,660 (M=2250, F=2410).

3.3.2. Study Population

The study population included all full-cycle primary school students who were registered and attending in the five selected representative schools (Robit, Woramit, Saint Hana, and Gurer (Dek Island) and Kunzila schools) during study period February 1, 2021 to May 12, 2021G.C and who were voluntary to participate and give written consent.

3.4. Sample Size Determination and Sampling Technique

3.4.1. Sample Size Determination

The sample size of this study was determined using single proportion formula as described by Naing *et al.* (2006) by considering 27.5% prevalence of STH from previous study in the area (Abebe Getnet and Seble Worku, 2015).

$$n = \frac{Z^2 P (1 - P)}{d^2}$$

Where; n = required sample size

Z = confidence level at 95% (standard value of 1.96)

P = prevalence 27.5%

d = margin of error at 5% (standard value of 0.05)

$$n = \frac{(1.96)^2 \times 0.275 (1 - 0.275)}{(0.05)^2} = 306$$

To minimize errors arising during sampling (to compensate for the potential non-response rate) 10% was added to the calculated sample size. Hence, this addition of contingency (10% of 306), gave 31. As a result, in total 337 schoolchildren were chosen to participate in the study.

3.4.2. Sampling Technique

A systematic random sampling method was used to include 337 study participants. By using sample proportion formula, a quota was allocated for all selected primary schools. The sample size (n) proportionally divided into the total number of children of each school (337/4660=0.0723). Then, /0.0723/ is the factor that multiple the study subjects when a quota allocated for all grade levels, Example 2314*0.0723=167.3022~167 participants were selected from (1-4) grade levels and 2346*0.0723=169.6158~170 participants were selected from (5-8)

grade levels from five primary Schools. Based on the above data, the number of students selected from five primary Schools such as, Robite primary School ($1452 \times 0.0723 = 105$), Woramit primary School ($970 \times 0.0723 = 70$), and Gurer primary School in Deki Island ($266 \times 0.0723 = 20$), Kunzila primary School ($915 \times 0.0723 = 67$), and Saint. Hana primary School ($1057 \times 0.0723 = 75$) participants were taken. From section (classroom) in all selected primary schools, the study participants were selected from each section using systematic random sampling using attendance list or roster as a frame in each school and grade levels.

The total number of students in the selected five schools was 4660 and this was divided by the calculated sample size, 337 to know the interval for selection ($13.83 \sim 14$). Lottery method was used to select the first participant and selection was continued at every 14 intervals through the whole sections of all the schools. The 337 students were selected until the last interval of the last section.

Before sample collection, a brief explanation about the aims of study was given to volunteers and information was collected using a structured questionnaire, which contained questions related to socio-demographic characteristics, behavioral characteristics of the students and environmental conditions.

3.5. Inclusion and Exclusion Criteria

3.5.1. Inclusion Criteria

This study considered voluntary schoolchildren or those whose guardian/caretaker were willing for the inclusion of their children in this study for provision of stool samples for examination. Besides, schoolchildren who did not receive anti-helminthic treatment in the last three weeks were included in the study

3.5.2. Exclusion Criteria

Schoolchildren or children whose guardian/caretaker were not voluntary for provision of stool samples for examination or who took medication or deworming for soil-transmitted helminthic infection during the study period or within the last three weeks were excluded from the study.

3.6. Study Variables

3.6.1. Dependent Variable

The dependent variable in this study was the prevalence of soil-transmitted helminthic infection.

3.6.2. Independent Variables

The possible independent variables in this study were: sex, age, grade level, residence, educational level of parent, source of drinking water, latrine system, family size, hand washing habit, playing on soil, eating raw-vegetable, shoes wearing habit, personal and environmental hygiene.

3.7. Data Collection Procedure

3.7.1. Questionnaire Survey

A structured questionnaire was prepared in English and translated into the local language (Amharic) before interviewing. Similarly, the consent form was also prepared in English, translated in to Amharic language to get consent of students or their parents/guardians inclusion in this study. A full verbal and written explanation about the objectives of study was given to all voluntary participants and they were counseled about soil-transmitted helminthes by the laboratory technologist. After obtaining informed consent, schoolchildren or their guardians were interviewed about socio- demographic, behavioral and environmental risk factors of STH infections. The items of the questionnaire included age and sex of the schoolchildren, parents' educational level, source of drinking water availability and habits of washing fruit and vegetables for feeding, and habits of walking barefooted.

3.8. Stool Sample Collection and Laboratory Methods

3.8.1 Stool Sample Collection

The selected students were provided labeled stool cup with clean wooden applicator stick and they were informed to bring 3 grams of fresh stool sample of their own. All the collected stool samples were transported to Bahir Dar University, Biomedical laboratory for processing. The stored samples in plastic stool cap were processed using Kato-Katz and modified Ritchie concentration sedimentation technique to detect the eggs and larvae of helminthes.

3.8.2 Kato-Katz technique –Cellophane fecal thick Smear

The Kato-Katz technique is the diagnostic method recommended for monitoring large-scale treatment programs implemented for control of STHs infection and easy to use in field.

A small amount of the fecal sample was placed on newspaper by taking clean wooden spatula and forced through the nylon screen (mesh) to separate fecal materials from the large debris. The screened fecal material was transferred to the template which was laid flat centrally on a microscope slide. The template hole completely filled with screened of 41.7 mg fecal material and leveled to the surface of the microscope slide. Then place one piece of cellophane square, which would be soaked in malachite green-glycerol solution over the fecal sample. The specimen is making to spread evenly under the cellophane tape by pressing it with microscopic slide (prepared for this purpose). The slide was placed on the bench with the cellophane upwards in 25°C for few minutes followed by packing in slide box to facilitate transportation to Bahir Dar University Biomedical laboratory. Finally, the Kato-Katz smears were examined systematically under the middle (10X) and high Power (40X) objectives microscopically to observe the ova or larvae of STH.

3.8.3. Ritchie's Concentration Procedures

A modified formol-ether concentration (Ritchie's concentration) was used to assess the presence of ova, larvae or adults of STH from schoolchildren in this study. About 0.5 gram of the stool sample was emulsified with about 2.5 ml of 10% formalin and 1 ml of ether. The emulsified faces was shaken properly and filtered with membrane filter cup. The filtrate in the concentration tubes were tightly capped and centrifuged for 3 minutes at 1500 rpm (revolution per minutes). Then, the tube would be removed from the centrifuge and the four layers formed would be observed from top to bottom (the top layer of ether, 2nd layer plug of fecal debris, 3rd layer 10%formalin and 4th layer the bottom sediment layer/ that contain parasite/). All the top three layers would be discarded and kept the tube on rack for some times. The sediments that contain the parasites at the bottom of the test tube were transferred to a microscope slide and covered with a cover slip (22mm by 22mm). The slides covered with cover slip were examined microscopically under 10x and 40x magnification power for the presence or absence of ova or larvae of STH.

Intensity of STH infections was determined following the standard procedure of the WHO guideline and interpreted by estimating eggs per gram (EPG) of stool, and classified according to established threshold as light, moderate, and heavy infection (Montresor *et al.*, 2002). Accordingly, EPG for *A. lumbricoides* (1–4,999) and for *T. trichiura* (1–999) were considered light infections. For hookworm, EPG of 1–1,999 was considered light infections (Montresor *et al.*, 2002). The corresponding EPG for moderate infection of the parasites (*A. lumbricoides*, *T. trichiura*, and *hookworms*) was 5,000–49,999, 1,000–9,999, and 2,000–3,999 respectively. Similarly, heavy infection with *A. lumbricoides* and *T. trichiura* was considered when EPG became >49,999 and >9,999, respectively and when >3,999 for hookworms. To get approximate number of EPG, the total number of each parasite eggs counted was multiplied by a factor of 24 (Montresor *et al.*, 2002).

3.9. Performance Evaluation of the Two Diagnostic Methods of STHs Detection

In this study, the two diagnostic techniques, Kato-Katz (KK) and Formol-ether concentration (FEC) techniques, was employed for detection of STH infections. However, they vary in their sensitivity, cost, simplicity and applicability. The Kato-Katz technique is mainly recommended to detect STHs infections. In effective diagnosis, detection methods must be accurate, simple and affordable for the whole subjects and provide results in short period of time to effective prevention and control measures (Abebe Fenta *et al.*, 2020).

Proper detection of STHs using sensitive diagnostic methods is crucial in the national STHs prevention and control strategies. The detection rate and performance of FEC, and KK methods for STHs was checked. The diagnostic agreements of the methods were evaluated by Kappa value, number of observed agreements, number of agreements expected by chance and standard error of Kappa. Kappa result was interpreted as follows: values $k \leq 0$ as indicating no agreement and $k = 0.01–0.20$ as none to slight, $k = 0.21–0.40$ as fair, $k = 0.41–0.60$ as moderate, $k = 0.61–0.80$ as substantial, and $k = 0.81–1.00$ as almost perfect agreement (Abebe Fenta *et al.*, 2020).

3.10. Data Reliability and Validity

To ensure reliable information, laboratory materials were pre-tested before the data collection; standard operating procedures were used for specimen collection and processing for maintain a good quality study. The study participants were interviewed with their mother tongue Amharic to

avoid confusion and misunderstanding about the questioners during the collection of socio-demographic and behavioral risk factors.

3.11. Data Analysis

All collected data were registered in laboratory logbook during the study period, entered in to statistical package for social sciences (SPSS) statistical software version 23 for analysis. Then, study findings were explained in words, tables and other statistical summary techniques. Descriptive statistics were used to calculate the frequency and percentage of socio-demographic characteristics of the study subjects. Different variables were summarized using frequency tables. For each site, the association between STH infection and sex, grade level, family size, residence, source of drinking water, fingernail cleaning habit, shoe-wearing habit and the effects of personal and environmental hygienic were analyzed by using Chi-square analysis. Logistic regression analysis was also used to determine the strength of association between different socio-demographic and behavioral factors with a STH parasitic infections (dependent variables) and results were described in terms of odds ratio (COR) and (AOR) at 95 % CI.). *P-values* less than 0.05 were considered statistically significant for the associations between dependent and independent variables for Univariate logistic regression but multivariate logistic regression *p*-value less than 0.25.

3.12. Ethical Considerations

The study protocol together with consent form was submitted to ethical review board of college of science Bahir Dar University. After getting ethical clearance, letter of support was written to Robite Primary School, Kunzila Primary School, Woramit Primary School, Saint Hana Primary School and Gurer Primary School in Deki Island full-cycle primary schools. The subjects were informed about the study and written informed consents were obtained from all of the participants before collecting the stool samples. Participation in the study was on voluntary basis and study subjects were free to withdraw from the study before and after collection of stool samples without losing any of the benefits they are supposed to obtain from the school.

4. RESULTS

4.1 Socio-Demographics Characteristics of the Participant

A total of 337 students were included and interviewed to collect fecal samples in the present study. Of these participants, 178(52.8%) were females while 159(47.2%) were males. One hundred five (31.16%) of the total study subjects were from Robit primary school, 75 (22.26%) from Saint Hana primary school, 70 (20.77%) from Woramite primary school, 67 (19.88%) from Kunzila primary School and 20 (5.93%) were from Gurer (Deki- Island) primary school. The mean age of the study subjects was 11.31 years with a minimum and maximum age of 5 years and 22 years, respectively. The majority of 330 (97.9%) of the study subject were Orthodox Tewahido religion followers and seven (2.1%) of the study subject were Muslims. Majority 176 (52.2%) of the schoolchildren were in the age group of 11-15 years followed by those in the age category of 5-10 years 135(39.9%), and 16-22 years 26(7.7%). Students belonging to grade levels 1-4 accounted for 201(59.6%) while those in grade 5-8 were 136 (40.4%). Based on the residence of the students, majority 273(81.0%) were rural dwellers while nearly one-fifth 64(19.0%) were from urban setting.

Table 3: Socio-demographic characteristics of the school age children (n=337) around Lake Tana, 2020/21

Variable	Categories	Frequency	Percentage (%)
Sex	Female	178	52.8
	Male	159	47.2
Age	5-10	135	40.1
	11-15	176	52,2
	16-22	26	7.7
Grade level	1-4	201	59.6
	5-8	136	40.4
Family size	1-3	47	13.9
	4-6	168	49.9
	More 6	122	36.2

Religion	Orthodox	330	97.9
	Muslim	7	2.1
Mather education level	Illiterate	242	71.8
	Primary school	65	19.3
	Secondary school	26	7.7
	College	4	1.2
Father education level	Illiterate	182	54
	Primary school	112	33.2
	Secondary school	39	11.6
	College	4	1.2
Residence of schoolchildren	Rural	273	81.0
	Urban	64	19.0
Number of students per school	Robite primary school	105	31.16
	Saint Hana primary school	75	22.26
	Woramite primary school	70	20.77
	Kunzila primary school	67	19.88
	Gurer primary school at Dek-Island	20	5.93
Total schoolchildren		337	100%

4.2. Soil-Transmitted Helminths Identified in School children around Lake Tana

The most dominant parasitic species identified in this study was hookworm with the prevalence of 88 (26.1%) followed by *A.lumbricoides* 50(14.8%) and *T.trichiura* 5(1.5%). Analysis of the distribution of STHs infection among the five full-cycle primary schools showed that the highest STH infection was 50 (34.7%) in schoolchildren of Robit school, followed by Saint Hana school was 42 (29.2%), Woramite school was 31 (21.5%), Kunzila school was 15 (10.4%), while the least infection was among schoolchildren of Gurere primary school (Dek-Island) school 6(4.2%).

Table 4: STHs identified among five governmental primary school children (n=337) around Lake Tana, 2020/21

Schools	Types of STHs			Total No (%)
	Hookworm No (%)	<i>A. lumbricoides</i> No (%)	<i>T. trichuria</i> No (%)	
Robite School	46 (52.3)	4 (7.8)	-	50 (34.7)
Woramite School	14 (15.9)	15 (29.4)	2 (40.0)	31 (21.5)
Kunzila School	4 (4.5)	11 (21.6)	-	15 (10.4)
Saint Hana School	20 (22.7)	20 (39.2)	2 (40.0)	42 (29.2)
Gurer (Dek) School	4 (4.5)	1 (2.0)	1 (20.0)	6 (4.2)
Total	88 (26.1)	50 (14.8)	5 (1.5)	143 (42.4)

Key: No-number of students and STHs-Soil-transmitted helminths

4.3. The Prevalence of STHs Infection

Out of the total 337 participants in the study, 129(38.3%) were infected with different types of STH infections. Of these, 72 (55.8%) of the STH infection were in males while the 57(44.2%) were among females. Hookworm infection was the most predominant STH in this study, which was detected in 88(26.1%) of the study subjects and *A. lumbricoides* was the second most frequent STH prevalent in 50(14.8%) of the study subjects. *T. trichiura* was the least prevalent geo-helminths in this study, detected only in five (1.5%) of the study subjects. One hundred fifteen (34.1%) of the study subjects had single helminthic infection, while double infection occurred in 14 (4.2%) individuals. The most frequent of double STH infection was those of *A. lumbricoides* and Hookworm 13(3.9%), followed by *S. mansoni* and hookworm 6(1.78%), *S. mansoni* and *A. lumbricoides* 4(1.19%) while the combination of *E. vermiculari* and hookworm was least 1(0.30%) frequent double STH infection. The prevalence of triple infection of *S.mansoni*, *Ascaris lumbricoides* and hookworm was 6(1.78%) while those of *H. nana*, *A. lumbricoides* and hookworm was 2(0.59%) and *E. vermiculari* , Hookworm and *A. lumbricoides* were 1(0.30%).

Table 5: The prevalence of soil transmitted helminthes in the study subject (n=337) around Lake Tana, Bahir Dar, northwest Ethiopia, 2020/21

Soil transmitted helminthes	No. of infection	Percentage (%)
Single infection		
Hookworm	74	22%
<i>Ascaris lumbricoides</i>	37	11%
<i>Trichiuris trichiura</i>	4	1.2%
Double infection		
Hookworm+ <i>Ascaris lumbricoides</i>	13	3.9%
Hookworm+ <i>Trichiuris trichiura</i>	1	0.3%
Total	129	38.3%

4.4. The Prevalence and Intensity of Soil Transmitted Helminthic Infection among Schoolchildren around Lake Tana.

Categorization of intensity of infection for STHs among schoolchildren around Lake Tana is shown in /Table 4.4/. For *A.lumbricoides*, the prevalence of light, moderate, and heavy infections were 39(90.7), 4(9.3%) and zero (0.0%), respectively. For hookworm and *T.trichiura*, there were no moderate and heavy infections in this study. The highest egg count for *A.lumbricoides*, hookworm and *T.trichiura* were 3552, 384 and 96 EPG, respectively. Overall, the intensity of STH was 61(93.8%) of the study participants had light infection and four (6.2%) of them had moderate infection of *A.lumbricoides* only.

Table 6: Categorization the intensity of soil transmitted helminthic infection among schoolchildren around Lake Tana 2020/21

STHs intensity of infection	Types of STHs infection			
	HW% n=18	AL% n=43	TT% n=4	All STH% n=65
Light	18(100%)	39(90.7%)	4(100%)	61(93.8%)
Moderate	0(0.0)	4(9.3%)	0(0.0)	4(6.2%)
Heavy	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Mean of EPG	173.33	607.26	72.00	

Key: AL- *A.lumbricoides*, EPG-No of eggs per gram, HW- hookworm, STHs-soil transmitted Helminthes, TT-*T.trichiura*

4.5. Association of Socio-Demographic Characteristics with STHs Infection

The association of STH infections with socio-demographic characters is described in /Table 4.5/. Chi-square analysis indicated that a statistically significant association between STHs infection with the socio-demographic factors including sex ($\chi^2 = 6.251, p = 0.012$), age ($\chi^2 = 6.365, p = 0.041$), grade level ($\chi^2 = 6.246, p = 0.012$), family size ($\chi^2 = 14.914, p = 0.001$), mothers' education ($\chi^2 = 32.899, p = 0.000$), fathers' education ($\chi^2 = 9.175, p = 0.027$) and Residence of SAC ($\chi^2 = 24.997, p = 0.002$). The above data showed that significantly association between STHs and socio-demographics factors', namely sex of children in which males were more vulnerable than females and children from rural areas were more infected than urban settlers.

However, significant association was not found between STHs infection and religion of schoolchildren ($\chi^2 = 1.742, P = 0.187$).

Table 7: The association of socio-demographics characteristic's with STH infection among schoolchildren (n=337) around Lake Tana 2020/21.

Factors	Categories	Total examined	STHs		χ^2	P-value
			Positive No (%)	Negative No (%)		
Sex	Male	159	72 (45.3)	87 (54.7)	6.251	0.012
	Female	178	57 (32.0)	121 (68.0)		
Age (year)	5-10	135	42 (31.1)	93 (68.9)	6.365	0.041
	11-15	176	73 (41.5)	103 (58.5)		
	16-22	26	14 (53.8)	12 (46.2)		
Grade	1-4	201	66 (32.8)	135 (67.2)	6.246	0.012
	5-8	136	63(46.3)	73 (53.7)		
Family size	1-3	47	19 (40.4)	28 (59.6)	14.914	0.001
	4-6	168	48(28.6)	120 (71.4)		
	More 6	122	62(50.8)	62 (49.2)		

Religion	Orthodox	330	128 (38.8)	202 (61.2)	1.742	0.187
	Muslim	7	1 (14.3)	6 (85.7)		
Mather education level	Illiterate	242	115 (47.5)	127 (52.5)	32.899	0.000
	Primary school	65	12 (18.5)	53 (51.5)		
	Secondary school	26	1 (3.8)	25 (96.2)		
	College	4	1 (25.0)	3 (75.0)		
Father education level	Illiterate	182	79 (43.4)	103 (56.6)	9.175	0.027
	Primary school	112	42 (37.5)	70 (62.5)		
	Secondary school	39	7 (17.9)	32 (82.1)		
	College	4	1 (25)	3 (75)		
Residence	Rural	273	122 (44.7)	151 (55.3)	24.997	0.000
	Urban	64	7 (10.9)	57 (89.1)		

Key: χ^2 =Chi-squire test, No: number of students, and STHs-Soil transmitted helminthes.

4.6. Associations of Potential Risk Factors with STH Infection among Schoolchildren around Lake Tana

More infections of STHs were recorded among those students whose family were occupationally farmer 43.5% (101/232), who had no the habit of washing their hands 60.7% (74/122) and those with no hand washing facilities in their schools 45.3% (72/158).

Around 45.3% (68/150) of student who had no knowledge about the routes of STHs transmission and 117 (40.8%) of the subjects who did not know the role of fecal contact as one of the means of STH transmission were infected as compared with those who had knowledge of the routes of STHs transmission.

Besides, 47.1% of the schoolchildren who had the habit of eating raw/unwashed fruits/vegetable and 34.5% of those who did not eat raw vegetable and those who knew about the prevention and control techniques of STHs infection but they were found to positive for at least one of STH infection was significant ($p=0.029$).

About 63.6%, 57.1%, 42% and 28.8% of the study participants who used river water, spring water, ground water and tap water as a source of drinking water respectively were STH infected.

The association between source of drinking water and STH infections was statistically significant ($P=0.002$).

There was statistically significant association between STH infection and shoes wearing habit of the study participants. Students who did not wear shoes at all were the most infected 61.1% (55/90) followed by those who wore shoes sometimes 66 (38.4%) as compared with those used shoes always 8(10.7%).

About two folds of 94 (48.5%) of STH infections were observed among students who defecated in open air than those who did not defecate in an open air 35 (24.5%) and place of defecation was significantly associated with risk of tightening STH infections ($p < 0.05$).

Increase in the rates of STH infection was observed as we go through the three categories of the variable ‘Practice of washing hands after toilet’. The rate of STH infections was 16 (21.6%) among SAC who always wash their hands after using toilet and the rate was relatively similar 30 (41.1%) vs 83 (43.6%) between participants who sometime wash their hands after toilet and those who did not wash their hands after using toilet at all. Likewise, the prevalence rate of STH infection was 31 (16.5%) among SAC who always washed their hands before meal, it was 74 (59.7%) among those who sometime washed their hands before meal, and remarkably the highest infection was 24 (96.0%) recorded in children who did not wash their hands before meal at all.

STH infection positivity was higher (47.1%) in students who had the habit of playing with soil than those who had no such habit (34.5%).

Table 8: Associations of potential risk factors with STH infection among schoolchildren (n=337) around Lake Tana, 2020/21.

Risk factors	Categories	Examined	STHS		χ^2	p-value
			Positives	Negatives		
			No (%)	No (%)		
Family occupation	Employed	17	2 (11.8)	15 (82.2)	10.672	0.014
	Farmer	232	101 (43.5)	131 (56.5)		
	Merchant	79	23 (29.1)	56 (70.9)		

	Other	9	3 (33.3)	6 (66.7)		
	Not at all	164	79 (48.2)	85 (51.8)		
Knowledge on route of STH transmission	No	150	68 (45.3)	82 (54.7)	5.694	0.017
	Yes	187	61 (32.6)	126 (67.4)		
Feces contact transmit diseases	No	287	117 (40.8)	170 (52.2)	5.067	0.024
	Yes	50	12 (24.0)	38 (76.0)		
Habit of eating unwashed vegetable	No	235	81 (34.5)	154 (65.5)	4.773	0.029
	Yes	102	48 (47.1)	54 (52.9)		
Knowledge on prevention and control of STH	No	237	105 (44.3)	132 (55.7)	12.271	0.000
	Yes	100	24 (24.0)	76 (76.0)		
Participation in irrigation	No	237	79 (33.3)	158 (66.7)	8.268	0.004
	Yes	100	50 (50.0)	50 (50.0)		
Sources of water	Ground water	138	58 (42.0)	80 (58.0)	14.957	0.002
	River	11	7 (63.6)	4 (36.4)		
	Spring	35	20 (57.1)	13(42.9)		
	Tape water	153	44 (28.8)	109 (71.2)		
Shoes wearing habit	Always	75	8 (10.7)	67 (89.3)	44.062	0.000
	Sometime	172	66 (38.4)	106 (61.6)		
	Not at all	90	55 (61.1)	35 (38.9)		
Availability of toilet	No	128	71 (55.5)	57 (44.5)	25.813	0.000
	Yes	209	58 (27.8)	151 (72.2)		
How often to use toilet	Always	150	37 (24.7)	113 (75.3)	21.242	0.000
	Sometime	84	42 (50.0)	42 (50.0)		
	Not at all	103	50 (48.5)	53 (51.5)		
Defecation on open space	No	143	35 (24.5)	108 (75.5)	20.033	0.000
	Yes	194	94 (48.5)	100 (51.5)		

Washing hand after toilet	Always	74	16 (21.6)	58 (78.4)	11.693	0.003
	Sometime	73	30 (41.1)	39 (53.4)		
	Not at all	190	83 (43.6)	111 (58.4)		
Washing hand before meal	Always	188	31 (16.5)	157 (83.5)	97.067	0.000
	Sometime	124	74 ((59.7)	50 (40.3)		
	Not at all	25	24 (96.0)	1 (4.0)		
Regular finger nail trimming	No	198	82 (41.4)	116 (58.6)	1.997	0.158
	Yes	139	47 (33.8)	92 (66.2)		
Playing on soil	No	235	81 (34.5)	154 (65.5)	4.773	0.029
	Yes	102	48 (47.1)	54 (52.9)		

Key: χ^2 =Chi-square test, No: number of students, p-value-probability value and STHs-Soil transmitted helminths.

4.7. Univariate Logistic Regression Analysis for Socio-Demographics Factors Associated with STH Infection around Lake Tana.

Univariate logistic regression model was used to assess the strength of associations of the overall STHs infection with the socio-demographic risk factors such as sex, age and residence of schoolchildren. Crude odd ratios (COR) obtained from univariate logistic regression analysis were shown in /Table 4.7/. Male students were about two times (COR=1.757, 95% CI = 1.13-2.7, $p = 0.013$) more likely to be infected by the STHs infections than their female counterparts. /Table-4.7/ Students from rural setting were 7 times (COR =6.579, 95%CI=2.90-14.94, $p=0.000$) more likely to acquire STHs infection than students who live in the urban area. There was no significant association between religion, mother and Fathers education and with STHs infection ($p=0.219$, $p = 0.474$), respectively.

Table 9: Univariate logistic regression analysis for socio-demographics factors associated with STH infection around Lake Tana, 2020/21

Factors	Categories	STHs		Crude OR	P-value
		Positives No (%)	Negative No(%)		
Sex	Male	72 (45.3)	87 (54.7)	1.757(1.128-2.737)	0.013
	Female	57 (32.0)	121 (68.0)	1	
Age	5-10	42 (31.1)	93 (68.9)	1.567(0.979-2.516)	0.061
	11-15	73 (41.5)	103 (58.5)	2.583(1.101-6.061)	
	16-22	14 (53.8)	12 (46.2)	1	
Grade	1-4	66 (32.8)	135 (67.2)	1.765(1.128-2.762)	0.013
	5-8	63(46.3)	73 (53.7)	1	
Residence	Rural	122(44.7)	151(55.3)	6.579(2.896-14.944)	0.000
	Urban	7(11.0)	57(89.0)	1	
Family size	1 to 3	19 (40.4)	28 (59.6)	1	0.123
	4 to 6	48(28.6)	120 (71.4)	0.589(0.301-1.154)	
	More 6	19 (40.4)	28 (59.6)	1.523(0.770-3.012)	
Religion	Orthodox	128 (38.8)	202 (61.2)	3.802(0.452-31.947)	0.219
	Muslim	1 (14.3)	6 (85.7)	1	
Mother of education	Illiterate	115 (47.5)	127 (52.5)	2.717(0.279-26.484)	0.390
	Primary	12 (18.5)	53 (81.5)	0.679(0.065-7.110)	
	Secondary	1 (3.8)	25 (96.2)	0.120(0.006-2.458)	
	College	1 (25.0)	3 (75.0)	1	
Father of education	Illiterate	79 (43.4)	103 (56.6)	2.301(0.235-22.543)	0.474
	Primary	42 (37.5)	70 (62.5)	1.800(0.181-17.868)	
	Secondary	7 (17.9)	32 (82.1)	0.656(0.059-7.280)	
	College	1 (25)	3 (75)	1	

Key: COR- Crude odds ratio, No: number of students, p-value-probability value and STHs-Soil transmitted helminths

4.8. Univariate logistic regression analysis for risk factors of STH infections among schoolchildren around Lake Tana

The univariate logistic regression analysis showed that the rate of STHs infection was significantly related to hand washing habit, open defecation, family occupation, water source used, shoes wearing habit, washing hand after toilet and before food and playing with soil. Schoolchildren who practiced open defecation were about three times more likely to be infected with STHs (COR =2.901, 95% CI = 1.806-4.659, $p < 0.001$) than students who did not practice an open field defecation.

There was significant difference in infection rate of STHs between SAC who did and did not wash their hands after toilet and before meal (Table 4.8). Schoolchildren who never washed their hands after toilet were about three times (COR=3.160, 95%CI=1.538-6.490, $p = 0.001$) more likely to acquire STHs infection than children who wash their hands always after toilet. The odds of STH infection was about 121times (COR=121.548, 95%CI=15.85-932.104, $p=0.000$) higher among schoolchildren who did not wash their hands before meal than those who always washed their hands.

SAC who never wore shoes at all were 13 times (COR=13.161, 95% CI=5.64-30.69, $p=0.000$) more likely to be infected with STHs than those who always wore shoes and schoolchildren who sometimes wore shoes were five times (COR=5.215, 95%CI=2.36-11.55, $p=0.000$) more likely to contract STHs infection than SAC who always wore shoes.

Schoolchildren who had habit of playing with soil were 5 times (4.665, 95%CI=2.89-7.54, $p=0.000$) more likely to contract STH infection as compared to those who did not play with soil. In contrast, other factors such as family occupation and frequency of body washing lacked significant association with infection of STHs.

Table 10: Univariate logistic regression analysis for risk factors of STH infections among SAC around Lake Tana, 2020/21

Factors	Categories	STHs		COR	P-value
		Positive No (%)	Negative No (%)		
Knowledge on route of STH transmission	No	68 (45.3)	82 (54.7)	1.713(1.099-2.668)	0.017
	Yes	61 (32.6)	126 (67.4)	1	
Feces contact transmit diseases	No	117(40.8)	170 (52.2)	2.179(1.093-4.347)	0.027
	Yes	12 (24.0)	38 (76.0)	1	
Habit of eating un-washing vegetable	No	81 (34.5)	154 (65.5)	1	0.030
	Yes	48 (47.1)	54 (52.9)	1.690(1.053-2.712)	
Knowledge on prevention and control of STH	No	105(44.3)	132 (55.7)	2.519(1.448-4.261)	0.001
	Yes	24 (24.0)	76 (76.0)	1	
Irrigation	No	79 (33.3)	158 (66.7)	1	0.004
	Yes	50 (50.0)	50 (50.0)	2.000(1.242-3.219)	
Sources of water	Spring	58 (42.0)	80 (58.0)	3.303(1.552-7.032)	0.002
	River	7 (63.6)	4 (36.4)	4.335(1.209-15.551)	0.024
	Ground water	20 (57.1)	13(42.9)	1.796(1.104-2.922)	0.018
	Tape water	44 (28.8)	109 (71.2)	1	
Shoes wearing habit	Always	8 (10.7)	67 (89.3)	1	0.002
	Sometime	66 (38.4)	106 (61.6)	5.215(2.355-11.547)	
	Not at all	55 (61.1)	35 (38.9)	13.161(5.643-30.694)	
Availability of toilet	No	71 (55.5)	57 (44.5)	3.243(2.044-5.146)	0.000
	Yes	58 (27.8)	151 (72.2)	1	
Deification in an open space	No	35 (24.5)	108 (75.5)	1	0.000
	Yes	94 (48.5)	100 (51.5)	2.901(1.806-4.659)	
Washing hand after	Always	16 (21.6)	58 (78.4)	1	

toilet	Sometime	30 (41.1)	39 (53.4)	2.580(1.382-4.816)	0.003
	Not at all	83 (43.6)	111 (58.4)	3.160(1.539-6.490)	0.002
Washing hand before diet	Always	31 (16.5)	157 (83.5)	1	
	Sometime	74 (59.7)	50 (40.3)	7.495(4.428-12.689)	0.002
Playing on soil	Not at all	24 (96.0)	1 (4.0)	121.548(15.850-932.104)	0.004
	No	81 (34.5)	154 (65.5)	1	
	Yes	48 (47.1)	54 (52.9)	4.665(2.887-7.537)	0.000

Key: COR- Crude odds ratio, No-number of students, p-value-probability value and STHs-Soil transmitted helminthes.

4.9. Multivariable Logistic Regression Analysis of Potential Risk Factors of STH Infections among Schoolchildren around Lake Tana.

The independent variables with a p -value < 0.25 in univariate logistic regression model were selected and included in multivariable logistic regression model. The bivariate logistic regression model deals with only a direct strength of associations of factors with STHs infection but does not control for confounding effect (Getaneh Alemu *et al.*, 2019).

In multivariable logistic regression analysis, hand washing after toilet, hand washing before food, shoes wearing habit, playing with soil, hand washing facility in school, residence and availability of toilet were remained statistically significant ($p < 0.05$) /Table 4.9/. Schoolchildren who did not wash their hand before meal were about 85 times (AOR = 85, 95% CI = 10.799 – 674.154) more likely to be infected with STHs than those children who always washed their hand. Similarly, students who washed their hand sometimes were 7 times (AOR = 6.83, 95% CI = 3.821-12.217) more likely to be infected with STHs than those students who washed their hand frequently. The odds of infection by STHs in those schoolchildren who live in rural area was about four times (AOR=3.748, 95%CI=1.558-9.117, $p=0.003$) more in schoolchildren who live in urban area around Lake Tana.

The other significant risk factor associated with prevalence of STHs among schoolchildren around Lake Tana was shoes wearing habit. SAC who had no shoes wearing habit and those who wore shoes sometime were 7 times (AOR=7.123, 95%CI=2.824-17.966) and 3 times

(AOR=2.878, 95% CI=1.216-6.810) respectively, more likely to be infected with STHs than schoolchildren who always wore shoes. The odd of occurrence of STHs infection in schoolchildren who played with soil was about four times higher than those schoolchildren who did not play with soil.

Table 11: Multivariable logistic regression for potential risk factors associated with STH infections among schoolchildren around Lake Tana, 2020/21

Factors	Categori es	STH- positive case (%)	COR(95% CI)	P- value	AOR(95%CI)	P-value
Sex	Male	72 (45.3)	1.757(1.128-2.737)	0.013	0.516(0.323- 0.826)	0.006**
	Female	57 (32.0)	1		1	
Grade level of SAC	1-4	66 (32.8)	1		1	
	5-8	63(46.3)	1.765(1.128-2.762)	0.013	2.164(1.316- 3.559)	0.002**
Religion of SAC	Orthodo x	128(38.8)	3.802(0.452- 31.947)	0.219	2.383(0.245- 23.203)	0.256
	Muslim	1 (14.3)	1		1	
Residence of SAC	Rural	122(70.5)	6.579(2.896- 14.944)	0.000	3.748(1.558- 9.017)	0.003**
	Urban	7(11.0)	1		1	
Habit of eating un- washing vegetable	No	81 (34.5)	1		1	
	Yes	48 (47.1)	1.690(1.053-2.712)	0.030	2.480(1.461- 4.210)	0.001**
Irrigation	No	79 (33.3)	1		1	
	Yes	50 (50.0)	2.000(1.242-3.219)	0.004	2.125(1.264- 3.575)	0.004**
Sources of water	Spring	58 (42.0)	3.303(1.552-7.032)	0.002	3.568(0.962- 13.224)	0.057
	River	7 (63.6)	4.335(1.209- 15.551)	0.024	3.704(1.681- 8.159)	0.001**

	Ground water	20 (57.1)	1.796(1.104-2.922)	0.018	2.125(1.264-3.575)	0.004*
	Tap water	44 (28.8)	1		1	
Shoes wearing habit	Always	8 (10.7)	1		1	
	Sometime	66 (38.4)	5.215(2.355-11.547)	0.000	2.878(1.216-6.810)	0.016*
	Not at all	55 (61.1)	13.161(5.643-30.694)	0.000	7.123(2.824-17.966)	0.000***
Availability of toilet	No	71 (55.5)	3.243(2.044-5.146)	0.000	2.706(1.460-5.010)	0.002*
	Yes	58 (27.8)	1		1	
Open space defecation	No	35 (24.5)	1		1	
	Yes	94 (48.5)	2.901(1.806-4.659)	0.000	1.774(0.910-3.556)	0.095
Washing hand after toilet	Always	16 (21.6)	1		1	
	Sometime	30 (41.1)	2.580(1.382-4.816)	0.003	1.916(0.989-3.710)	0.054
	Not at all	83 (43.6)	3.160(1.539-6.490)	0.002	2.186(1.017-4.698)	0.045*
Washing hand before diet	Always	31 (16.5)	1		1	
	Sometime	74 (59.7)	7.881(1.686-4.924)	0.000	6.833(3.821-12.217)	0.000***
	Not at all	24 (96.0)	121.548(15.850-932.104)	0.000	85.325(10.799-674.154)	0.000***
Playing on soil	No	81 (34.5)	1		1	
	Yes	48 (47.1)	4.665(2.887-7.537)	0.000	4.220(2.585-6.882)	0.007**

Key: AOR – adjusted odds ratio, 95%CI -95% confidence interval, COR- Crude odds ratio, *p*-value-probability value, SAC-school-age children and STHs-Soil transmitted helminthes.

4.10. Comparison of the Performance of Ritchie's Concentration and Kato-Katz Diagnostic Methods in STHs Detection by using

The aim of this comparison was to evaluate the operational characteristics by using the two methods for the detection of STHs infection. The overall prevalence of STHs infection was 38.3%. The prevalence of hookworm, *A. lumbricoides* and *T.trichiura* infections by two methods was 26.1%, 14.8%, and 1.5%, respectively. The observed agreement of *A. lumbricoides* = $(17+285)/337 = 0.896$ and Expected agreement by chance = $\frac{(43 \times 26)/337 - (294 \times 311)/337}{337} = 0.795$

The *A. lumbricoides* Actual agreement beyond chance = $0.896 - 0.795 = 0.101$ and Potential agreement beyond chance = $1 - 0.795 = 0.205$ then kappa value = $0.101/0.205 = 0.49$ (moderate agreement) between the two test.

The observed agreement of Hookworm = $(13+249)/337 = 0.777$, Expected agreement by chance = $\frac{(18 \times 83)/337 - (319 \times 254)/337}{337} = 0.700$

The Hookworm Actual agreement beyond chance = $0.777 - 0.700 = 0.077$ and Potential agreement beyond chance = $1 - 0.700 = 0.300$, then kappa value of Hookworm = $0.077/0.300 = 0.26$ (fair agreement) between the two test.

The observed agreement of *T.trichiura* = $(0+332)/337 = 0.985$ Expected agreement by chance = $\frac{(4 \times 1)/337 - (333 \times 336)/337}{337} = 0.985$

The *T.trichiura* actual agreement beyond chance = $0.985 - 0.985 = 0.000$ and Potential agreement beyond chance = $1 - 0.985 = 0.015$, then kappa value of *T.trichiura* = $0.000/0.015 = 0.000$ (: value $k \leq 0$ as indicating no agreement) between the two test.

The strength of agreement of the two diagnosis methods was determined by kappa value. The kappa value of *A. lumbricoides* was ($k=0.49$) this shows moderate agreement between the two test. The kappa value of Hookworm was ($k=0.26$) this shows fair agreement between the two test. The kappa value of *T.trichiura* was ($k=0.000$) this shows value $k \leq 0$ as indicating no agreement) between the two test. The kappa test is a statically methods for assessing the level agreement between two or more diagnostic methods measured on a dichotomous scale.

Kappa ranges from one (complete agreement beyond chance) to zero (agreement is equal to that expected by chance), whereas negative values indicate agreement less than is expected by chance. Because the magnitude of kappa is influenced by the prevalence of the disease (i.e., increase in prevalence increases kappa value).

Table 12: 337 Schoolchildren were tested for STHs detection by using two tests; Ritchie’s concentration as a standard test and Kato-Katz as a new test, show the level of agreement between the two tests by using Kappa-value.

Spp	KK “New test”	Ritchie’s concentration “As standard test”							
		Pos .	Neg	Tot al	Sen (%)	Spe (%)	Ppv %.	Npv %	Kappa-value
AL	Pos.	17	26	43	65.4	91.6	39.5	96.9	0.49
	Neg	9	285	294					
	Total AL	26	311	337					
HW	Pos.	13	5	18	15.7	98	72.2	78.1	0.26
	Neg	70	249	319					
	Total HW	83	254	337					
TT	Pos.	0	4	4	0	98.8	0	99.7	0.000
	Neg	1	332	333					
	Total TT	1	336	337					

Key: AL: *Ascaris lumbricoides*, FEC: Modified formol-ether concentration, HW: Hookworm, KK: Kato-Katz, NPV: negative predictive value, Pos: positive, PPV: positive predictive value, Sen: sensitivity, Spe: specificity, and TT: *Trichuris trichiuria*,

5. DISCUSSION

Soil-transmitted helminthiasis is a serious public health concern in several tropical and sub-tropical countries with depleted resource, poor socio-economic status and personal hygiene. Ethiopia is one of such countries with high prevalence of STH infection. Most of the time the burden of these parasites is high in school age children (SAC) and associated with high morbidity, mortality and economic loss to the countries (Fikreslasie Samuel *et al.*, 2017). Thus, knowledge about the distribution and extent of these neglected tropical diseases in a given community is important to identify vulnerable group and design appropriate intervention program. The present study attempted to assess the prevalence of soil-transmitted helminthic infection and their associated risk factors among schoolchildren in five selected primary schools around Lake Tana, northwest Ethiopia.

The overall prevalence of STHs infection among schoolchildren around Lake Tana, northwest Ethiopia, was about 38.3%. The result was almost in agreement with the result in Southern Ethiopia; with the prevalence of (38.3%) (Teklemariam Ergat and Abebe Demesew, 2019), However, it was greater than the study results in Birbir, Southern Ethiopia (21.1%) (Getaneh Alemu *et al.*, 2019), Butajira Town, South-Central Ethiopia (23.3%) (Teha Shumbej *et al.*, 2015), Gurage zone (9.5%) (Habtamu Weldesenbet *et al.*, 2019) and the prevalence of STH in Debre Tabor (13.2%) (Lemma Workineh *et al.*, 2020). Nevertheless, the present prevalence rate of STH infection was less than the reports of studies done in Nigeria (54.8%) (Karshima, 2018), and that done in the Amhara National Regional State, northwest Ethiopia 40.8% (Abebe Fenta *et al.*, 2020). These differences might be due to differences in parasitological methods used, sample size, drinking water source, level of personal hygiene sanitation, size of family, family's educational status, and environmental condition.

In the present study, three of the major STH species were identified. Of which, hookworm was the predominant 88(26.1%), followed by *A. lumbricoides* 50 (14.8%) and the least prevalent STH in the study area was *T. trichiuria* (1.5%). In this study, hookworm species was the most common STHs detected among the schoolchildren. This finding is consistent with report of a similar previous study, which detected hookworms, *A. lumbricoides* and *T. trichiura* in 46.9, 13.9, and 2.3% of the children, respectively (Tilahun Alelign *et al.*, 2015).

In our study, open field defecation and unavailability of toilet at household level were the major risk factors of hookworm infections. In addition, hookworm was the most prevalent among schoolchildren in the study area. This could be the fact that degrees of soil contamination with night soil, high duration of soil contact with skin or most individual have habit of walking barefooted.

Among the total respondents, 61.1% (55/90) of schoolchildren infected by STH who was never wore shoes the result show that at least two times higher than whom sometime wear shoes 38.4% (66/172) and also 6 times higher than those who always wear shoes 10.7% (8/75) respectively. The study also shows that the living style and nature of the occupation of individuals influenced the infection rate of STH. Example, among all schoolchildren that participates in the study 101(43.5%) of them come from farmer family that was highly infected with STHs than other types of occupation like merchant 23(29.1%) and employed two (11.8%). Still farmers respondents spending more time in their farm that area is suitable for infective larval stage (L3) of Hookworm easily penetrate human skin. In this study male were more infected by hookworm than female due to males are more likely to involve in outdoor activities than female because of social and religion restriction. In addition, the outdoor environments including agricultural areas are commonplace for open defecation by male during working time.

The prevalence of hookworm infection in this study was (26.1%) which is higher than the previous findings such as 6.25% prevalence in Sekela (Addisu Tolera and Mebrate Dufera, 2020), 5.5% in Tillie town (Alamneh Abera and Endalkachew Nibret, 2014). 3.2% in Debre Tabor town (Lemma Workineh *et al.*, 2020), 7.2% in Bahir Dar (Abebe Getnet and Seble worku, 2015), 2.8% in Ambo Town (Fikreslasie Samuel *et al.*, 2017) and 14.5% in Arbaminch Zuria district (Getaneh Alemu *et al.*, 2018).

On the other hand, the prevalence of hookworm infection in this study area is lower than the results of previous studies conducted in different areas of Amhara Region namely 46.9% in Debub Achefer (Tilahun Alelign *et al.*, 2015), 43.4% in Zegie peninsula (Merem Abdi *et al.*, 2017) and 33.1% of hookworm infection prevalence in Motta town (Mulusew Adalem, 2014). This variation in prevalence might be due to differences in altitude, environmental condition, socio-economic and behavioral factors of the residents.

A. lumbricoides was the second most 50 (14.8%) prevalent species identified in this study, which is similar with the study conducted in Durbete Town with the prevalence of (13.9%) (Tilahun Alehign *et al.*, 2015). On the other hand, the finding of this study is lower than the finding of previous school based study in deferent areas. Such as, (38.0%) prevalence in Southern Ethiopia, (Tilahun Eyamo *et al.*, 2019), 28.5% of *A. lumbricoides* prevalence in Jimma Town, Southwestern Ethiopia (Zelege Mekonnen *et al.*, 2020) and 42.9% result reported from Gena Bossa, Southern Ethiopia, (Abebe Demissie and Teklemariam Ergot, 2019).

The prevalence of *A. lumbricoides* in present study area (14.8%) was slightly higher than the finding of previous study in Bahir Dar (12.7%) (Abebe Getnet and Seble worku, 2015). It is also higher than a 7.8% of *A. lumbricoides* prevalence report from Ambo town (Fikreslasie Samuel *et al.*, 2017). Such difference might have arisen due to differences in the environmental condition; personal hygiene and sanitation of the study subjects and the durability of *A. lumbricoides* ova probably have played an important role for the highest prevalence rate of *A. lumbricoides* in the current study area (Fikreslasie Samuel *et al.*, 2017). The high productiveness, the adult female worm that can produce 200,000 eggs per day, as well as the sticky nature of the shell of *A. lumbricoides* egg, which aids its attachment on human hands, fruits and vegetables, might have also contributed for high prevalence of this worm (Fikreslasie Samuel *et al.*, 2017). Therefore, poor sanitary condition and the life style of respondent and socioeconomic characteristics the study area is a major risk factor to *A. lumbricoides* transmission.

The prevalence of *T. trichiura* infection in this study was five (1.5%) which is almost similar to the finding of a study done in Libo kem district (1.6%) (Tsefahun Addisu and Achenef Asmamaw, 2015), and the finding in ambo town, western Ethiopia, the prevalence of *T. trichiura* among elementary school children was (2.2%) (Fikreslasie Samuel *et al.*, 2017). Nevertheless, the present result is slightly greater than the result of study conducted in Guragie zone with prevalence (0.5%) (Habtamu Weldesenbet *et al.*, 2019) and the result in Medebay Zana Wereda, North Western Tigray (0.5%) (Tsega Teshale *et al.*, 2018). To the contrary, the prevalence of *T. trichiura* in the current study was less than the prevalence rates reported from the Southwest Ethiopia (66.8%) (Eyob Tekalign *et al.*, 2019), Jimma town (47.6%) (Serkadis Debalke *et al.*, 2013), and in Nigeria (31.9%) (Karshima, 2018). This could be due to the environmental

condition; contaminated soil reached the food, drink or hands of a person and is subsequently ingested. SAC have frequent contact with soil because of their soil-loving behavior and put their contaminated hands inside their mouth.

The AOR of infection by STHs in schoolchildren who live in rural area was about four (95%CI: 1.558- 9.017) times more likely to acquire STH infections than those who live in the urban area. This result is almost in agreement with the results of Getaneh Alemu *et al.*(2019) in Birbir, Southern Ethiopia and those of Teklemariam Ergat and Abebe Demissie (2019) finding in Gena Bossa, Southern Ethiopia. This is perhaps, children in rural area might be more engaged in outdoor activities like farming as a result they have more exposure to those STH parasitic infections than urban.

School age children who had the habit of washing their hands after toilet who washed sometime were 2.58(95% CI: 1.382-4.816) times higher than those who always washed their hands. This finding least likely to acquire STH infection compared with the result of Bamlaku Tadege and Techalew Shimelis (2017) around Lake Hawassa, Southern Ethiopia. The respondents in this study, who never washed their hands after toilet were three (95%CI: 1.539-6.490) times more likely to be infected with STH infections than those who always washed their hands after toilet. This factor more associated with STH infection than reported by Lemma Workineh *et al.* (2020) in Debre Tabor, North West Ethiopia.

STH infection was significantly associated with the habit of hand washing before eating food ($p < 0.05$). The odds of acquiring STH infections among children who washed their hands sometimes before eating was 6.833(95%CI: 3.428-12.821) times higher than those children who washed their hands always before eating meal. This finding is similar to a report of a study conducted among schoolchildren in Zegie Peninzula (Merem Abdi *et al.*, 2017). Schoolchildren who never washed their hands before food eating were 85 (95%CI: 10.779-674.154) times more likely to acquire STHs infection than those respondent who washed their hands always before eating meal. This finding is also similar to finding reports in Addisu Tolera and Mebrate Dufera (2020) at Sekela town, western Ethiopia. This is probably due to low awareness of children about the

transmission of STH infections through their unwashed hands and even might be low educational status of mothers resulting poor hygiene household materials and childcare.

The other factor that found to increase the likelihood of STH infection among children was the place where SACs defecate. Children who had practice of open defecation were about three (95%CI: 1.806-4.659) times likely to acquire STH infections when compared to those who use latrine. This result was similar to the study reported by Fikreslasie Samuel *et al.* (2017).

There was no significant association between religion and rate of STHs infection in this study. The result was in accordance with the results of previous studies done in Bahir Dar (Agumas Ayalew *et al.*, 2019) and (Tamirat Hailegebriel, 2017).

Using spring water as source of water was significantly associated with the risk of STH infection with an AOR of four (95% CI: 0.962, 13.224) times. The likelihood of STH infections was four (95% CI: 1.681, 8.159) and two (95% CI: 1.264, 6.810) times higher among respondents who fetch water from river and use ground water than who used tap water respectively. The result is in accordance with the report in Jimma Town, Southwestern Ethiopia, (Zelege Mekonnen *et al.*, 2020). This could be due to the reasons that open field defecation, poor environmental situations may contaminate such water source, and this is likely increase risk of the infection.

This study considered the results of Ritchie-concentration and Kato-Katz techniques as for the Sensitivity, Specificity, Negative predictive value, Positive predictive value and kappa-value of the two techniques for STHs detection.

With regard to the sensitivity and specificity, Ritchie's concentration-technique was more preferable for Hookworm screening than *A.lumbricoides* and *T.trichiura* but Kato-Katz-technique was more effective than Ritchie's concentration for *A. lumbricoides* and *T. trichiura* detection. Based on this data single Kato-Katz techniques screening had significantly lower detection capacity than the Ritchie's concentration methods in diagnosing hookworm. Compared to Ritchie's concentration techniques, the Kato-Katz techniques had high sensitivity for detection of *A.lumbricoides* and *T.trichiura* than Hookworm screening testing. The sensitivity of Kato-Katz-technique in *A.lumbricoides* screening was 65.4%, this means that 65.4% of the diseased respondent screened by the test would be given "true positive" and the remaining 34.6% a false

negative results. This Kato-Katz diagnosis technique had high power of false negative avoidance value than the Ritchie's concentration techniques that means the sensitivity of *A.lumbricoides* in Ritchie's concentration techniques was 15.7% of the diseased individuals screened by the test would give "true positive" and the remaining 84.3% a false negative value.

The specificity of Ritchie's concentration techniques also had high capacity of false positive avoidance than Kato-Katz diagnosis technique. Example specificity of Hookworm was 98% of the diseased respondent screened by the test would give true negative and others 2% were false positive in Ritchie's concentration techniques. Those two-diagnostic technique comparisons are similar to a report of a study conducted among schoolchildren in the Amhara national regional state, northwest Ethiopia (Abebe Fenta *et al.*, 2020).

The strength of agreement of the two diagnosis methods was determined by kappa value. The k-agreement between Ritchie's concentration techniques and Kato-Katz techniques for the diagnosis of *A.lumbricoides*, *T.trichiura* and Hookworm was varying in their sensitivity, cost, simplicity and applicability. The agreement of FEC technique with the Kato-Katz techniques results was the kappa value of *A. lumbricoides* was (k=0.49) this shows moderate agreement between the two test. The kappa value of Hookworm was (k=0.26) this shows fair agreement between the two test. The kappa value of *T.trichiura* was (k=0.000) this shows value $k \leq 0$ as indicating no agreement) between the two test. Kappa ranges from one (complete agreement beyond chance) to 0 (agreement is equal to that expected by chance), whereas negative values indicate agreement less than is expected by chance. This finding was closely related with the previous study done in Amhara region, northwest Ethiopia (Mengistu Endris *et al.*, 2020). These differences in diagnostic performance might be due to interpersonal skill variations and technical errors of the two methods.

Strengths and Limitation of the Study

Strengths:

- ✚ The study included all five selected primary school around Lake Tana to show the actual prevalence of STH infection
- ✚ The study focused on one of the most vulnerable groups of the population
- ✚ The non-response rate was almost none
- ✚ The study was used two diagnostic techniques for STH identification rather than one

Limitations:

- ✚ The SAC might give false positive or false negative response during face-to-face interview during the research questionnaires
- ✚ In the questionnaire some important factors like history of travel and family income were not mentioned
- ✚ There was shortage of laboratory instruments by this reason we did not double or triple Kato-Katz-techniques.

6. CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The overall prevalence of soil-transmitted helminthic infection among SACs in and around Lake Tana was 38.3%. In the present study, 88 (26.1%), 50 (14.8%) and five (1.5%) SACs were infected with hookworm, *A.lumbricoides* and *T. trichiura*, respectively. About 14 (4.2%) of participants had double infection of hookworm and *A.lumbricoides*. Only one (0.3%) of participant had double infection of hookworm and *T. trichiura*. Multivariate logistic regression analysis result indicated that habit of wearing shoes, hand-washing practice, and source of water, habit of defecation system, sex, grade level and residence were the common associated risk factors for STH infections. Being urban dwellers and having family members with less than three children were found to be preventive. Lack of latrine, playing barefooted, untrimmed fingernail, eating raw vegetables, and absence of toilet availability were also the major risk factors. The sensitivity and negative predictive value testing between the two methods, Ritchie's concentration -technique was more preferable for hookworm screening than *A. lumbricoides* and *T. trichiura* but Kato-Katz technique was more effective than Ritchie's concentration for *A.lumbricoides* and *T. trichiura* detection.

6.2 Recommendation

Based on the finding of the present study, the following are recommended:-

- ❖ School-based strategic drug administration and following up its effective implementation is as a vital to control of STH parasitic infections.
- ❖ Education sector along with school community should encourage students' parents and community partnership to actively participate in school hygiene and sanitation club or programs.
- ❖ SACs and their guardians should be informed the risk of going barefooted and students should be encouraged to wear shoes.
- ❖ Awareness creation education about the potential risk of open defecation and feco-oral transmission of STH infection should be provided to the community.
- ❖ This survey demonstrated a high prevalence of hookworm in five schools around Lake Tana thus further studies are needed to determine what species of hookworm is endemic in this area.

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8. APPENDICES

Appendix A: Data Construction Form

BAHIR DAR UNIVERSITY
COLLEGE OF SCIENCES
DEPARTMENT OF BIOLOGY

Title: To determine the prevalence and associated risk factor of soil-transmitted helminthic infections among school-age children in five governmental schools around Lake Tana, Amhara regional state, Northwest Ethiopia.

Questionnaire (English version)

The objective of this study is to determine the prevalence and associated risk factor of soil-transmitted helminthic infections among school-age children in five governmental schools around Lake Tana, Amhara regional state, Northwest Ethiopia. You are cordially invited to participate in this study by responding to the following questions and providing stool samples.

I General information

001. School Name: _____

002: Student Name: _____

003. Student Code: _____

004. Date of collection: _____

II Baseline Socio demographic characteristics of students

Code	Characteristics	Classification
101	Sex	1. Male 2. Female
102	Age	_____years
103	Grade	_____
104	Place of residence	1. Urban 2. Rural
105	Religion	1. Orthodox 3. Muslim 2. Protestant 4. Others
106	Family size	1. from 1-3 2. From 4-6 3. More than 6
107	Mother education	1. No education 3. Secondary 2. Primary 4. College and above
108	Father education	1. No education 3. Secondary

		2. Primary	4. College and above
109	Family occupation	1. Farmer 2. Government employee	3. Merchant 4. Others
110	Do you have some knowledge on the route of transmission of intestinal soil transmitted helminthes?	1. Yes	2. No
111	Do you think human feces transmit disease?	1. Yes	2. No
112	Do you have habit of eating un washing vegetable?	1. Yes	2. No
113	Do you have some Knowledge on the prevention and control of STH infections	1. Yes	2. No
114	Are you participating in Irrigation?	1. Yes	2. No
115	Where is the source of drinking water?	1. Tape water 2. Spring water	3. River 4. Ground water
116	Do you have shoe wearing habit?	1. Always	2. Sometimes 3. Not at all
117	Toilet availability in your house?	1. Yes	2. No
118	How often use in the toilet?	1. Always	2. Sometimes 3. Not at all
119	Do you defecate in open space?	1. Yes	2. No
120	Do you wash your hand after toilet?	1. Always	2. Sometimes 3. Not at all
121	Do you have Hand washing habit before diet?	1. Always	2. Sometimes 3. Not at all
122	Have you Regular fingernail trimming?	1. Yes	2. No
123	Are you Playing with soil?	1. Yes	2. No

		2. የመጀመሪያ ደረጃ ከዚያ በላይ	4. ኮሌጁ እና ከዚያ በላይ
108	የአባት የትምህርት ደረጃ	1. ያልተማረ 2. የመጀመሪያ ደረጃ ከዚያ በላይ	3. ሁለተኛ ደረጃ 4. ኮሌጁ እና ከዚያ በላይ
109	የቤተሰብ የስራ ሁኔታ	1. ገበሬ 2. የመንግስት ሰራተኛ	3. ነጋዴ 4. ሌላ
110	የሰው አይነምድር በሽታ ያስተላልፋል ብለሽ/ህ ታምናለህ/ሽ?	1. አዎ	2. የለም
111	የሆድ ውስጥ ጥገኛ ትላትሎች እንዴት እንደሚተላለፉ የተወሰነ እውቀት አለህ/ሽ?	1. አዎ	2. የለኝም
112	አታክልትና ፍራፍሬ ሳታጥብ/ቢ የመጠቀም ልምድ አለህ/አለሽ?	1. አዎ	2. የለኝም
113	የሆድ ውስጥ ጥገኛ ትላትሎች/ በሽታዎች እንዴት መከላከልና መቆጣጠር እንደምቻል የተወሰነ እውቀት አለህ/ሽ?	1. አዎ	2. የለም
114	የመስኖ ስራ ላይ ይሳተፋሉ	1. አዎ	2. የለም
115	የመጠጥ ወሀ ከየት ነው የምትጠቀም/ሚ?	1. ከቧንቧ 2. ከምንጭ	3. ከወንዝ 4. ከጉድጋድ
116	ጫማ የመልበስ ልምድ አለውት?	1. ሁልጊዜ አላወቅም 2. አልፎአልፎ	3. ጫማ ዲሪን
117	ከቤት ሽንት ቤት አላችሁ?	1. አዎ	2. የለም
118	ካለ ሁልጊዜ ይጠቀማሉ?	1. አዎ	2. አልፎ አልፎ 3. አልጠቀምም
119	ሜዳ ላይ የመጸዳዳት ልምድ አለዎት?	1. አለኝ	2. የለኝም
120	ከሽንት ቤት መልስ እጅህን/ሽን የመታጠብ ልምድ ምንድነው?	1. ሁልጊዜ እታጠባለሁ 3. አልታጠብም	2. አልፎ አልፎ
121	ከምግብ በፊት እጄ መታጠብ ልምድ ምን ያክል ነው?	1. ሁልጊዜ እታጠባለሁ 3. አልታጠብም	2. አልፎ አልፎ
122	ጥፍርን የማጥዳት ልምድ አለዎት?	1. አለ	2. የለም
123	አፈር ላይ የመጫዎት ልምድ አለዎት?	1. አለኝ	2. የለኝም

Consent form

Appendix C: consent form (English)

Code _____

Dear participants:

I am a student of Masters Science at Bahir Dar University in college of science. I am going to conduct academic research in partial fulfillment of the requirement for the degree of Master of Science on the prevalence of soil transmitted helminthic infection and their associated risk factors among five selected full cycle primary school students. Such as, saint Hana School, Robite school (in Bahir Dar City administration), Kunzila School (in North Achefer Woreda), Woramit School and Gurer School in Deki Island (Bahir Dar Zuria Woreda) around Lake Tana. Therefore, you are invited to be a participant of this study by giving an appropriate response to questioners regarding this issue. If you agree to participate in the study please put your answers for questions given to you. Participation in the study is voluntary, you have the right to refuse from participating in this study at any time, and refusal to participate will not result loss of any benefit you receive. However, your participation in this study of prevalence of soil transmitted helminthes and their associated risk factors at saint Hana school, Robite school (in Bahir Dar City administration), Kunzila school (in North Achefer Woreda), Woramit school and Gurer school in Deki island around Lake Tana will be very important. If you have understood the explanation, I kindly request you to participate in the study.

Put your signature as illustrated below

Participant's response:

"I am clear about the study and agree to participate".

Participant's signature _____ date _____

የስምምነት ቅጽ

Appendix D: consent form (Amharic)

መለያ _____

እኔ በባህር ዳር ዩኒቨርሲቲ በሳይንስ ትምህርት ክፍል የሁለተኛ ዲግሪ ተማሪ ስሆን የሁለተኛ ዲግሪ ትምህርቴን ለማጠናቀቅ ጥናታዊ ጽሁፍ በመስራት ላይ እገኛለሁ። የጥናቱ ዋና ዓላማ በአማራ ክልል በጣና ሐይቅ ዙርያ ባሉ 5 የመንግስት አንደኛ ደረጃ ትምህርት ቤቶች ማለትም በሮቢት፣ ቅድስት ሀና ፣ በቁንዝላ፣ ወራሚትና ጉረር (ደቅ ደሴት) አንደኛ ደረጃ ሙሉ ሳይክልትምህርት ቤት በሚማሩ ተማሪዎች በአፈር ንክኪ የሚመጡ የትላትል ስርጭት ላይ ጥናት ማድረግ ነው ስለዚህ ያንተ/ቺ በፈቃደኝነት በዚህ ጥናት መሳተፍ ለጥናቱ መሳካት ጉልህ አስተወጽኦ ይኖረዋል። አንተ/ቺ የምትሰጠው/ጭው ማንኛውም አይነት መረጃ ለጥናታዊ ፅሁፍ ካልሆነ በስተቀር ለሌላ ጉዳይ ስለማይውል አንተ/ቺ ከዚህ ስጋት ነጻ ሆነህ /ሽ በራስ በመተማመን ግልጽ የሆነ መረጃ ትሰጠን/ጭን ዘንድ በትህትና እጠይቃለሁ።

የተሳታፊ ፊርማ _____ ቀን _____

ስለትብብርህ/ሽ ልባዊ ምስጋና አቀርባለሁ!!

Appendix E: Multivariable logistic regression model summary for potential risk factors of STH infection

Variables in the Equation

	B	S.E.	Wald	Df	Sig.	Exp(B)	95% C.I. for EXP(B)	
							Lower	Upper
Shoe_wearing			18.541	2	.000			
Shoe_wearing(1)	1.963	.472	17.305	1	.000	7.123	2.824	17.966
Shoe_wearing(2)	1.057	.439	5.788	1	.016	2.878	1.216	6.810
Offten_usetilet			11.378	2	.003			
Offten_usetilet(1)	.621	.330	3.535	1	.060	1.861	.974	3.556
Offten_usetilet(2)	1.222	.367	11.060	1	.001	3.393	1.652	6.971
Washing_Bdiet			52.611	2	.000			
Washing_Bdiet(1)	4.446	1.055	17.777	1	.000	85.325	10.799	674.154
Washing_Bdiet(2)	1.922	.297	42.002	1	.000	6.833	3.821	12.217
Constant	-3.225	.458	49.592	1	.000	.040		

a. Variable(s) entered on step 1: Shoe_wearing, Offten_usetilet, Washing_Bdiet.

Ethical Clearance Approval Form



Appendix G: Image shows the processes from data collection to the finding of STHs eggs in the sample collected during study time.