UNIVERSITY OF GHANA, LEGON

COLLEGE OF BASIC AND APPLIED SCIENCES

DEPARTMENT OF ANIMAL BIOLOGY AND CONSERVATION SCIENCE

IMPACT OF COVID-19 OUTBREAK ON THE PREVALENCE OF SOIL TRANSMITTED HELMINTHS AMONG SCHOOL CHILDREN IN THE VOLTA REGION OF GHANA.

BY

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THIS THESIS SUBMITTED TO UNIVERSITY OF GHANA, LEGON IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF PHILOSOPHY IN APPLIED PARASITOLOGY.

DECEMBER, 2021

DECLARATION

I hereby declare that this thesis presented to the Department of Animal Biology and Conservation Science in partial fulfilment for the award of M. Phil. Degree, is a true account of my own work except for the references that have been duely acknowledged.

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DEDICATION

I would want to dedicate this work first and foremost to the Almighty God, and secondly to my parents, Mr. and Mrs. Vorsah.

ACKNOWLEDGEMENTS

My heartfelt gratitude goes to the Almighty God for his Grace, strength, mercies and wisdom during the duration of this effort. My sincere thanks go to my supervisors, Dr. Daniel Oduro and Dr. I. F Aboagye, for their time, insight, and encouragement during my research. I am extremely thankful to Dr. Benjamin Ofori-Yeboah and Jones Quartey for their invaluable assistance, guidance, patience, and criticism during my work. God bless you abundantly. My heartfelt thanks also go to the headmaster and all of the staff at Jim Bourton Memorial Agricultural SHS for allowing me to use their laboratory for the diagnostic work.

I would want to express my gratitude finally to all of the lecturers, laboratory technicians and colleagues in the Department of Animal Biology and Conservation Science at the University of Ghana, Legon, who made this research a success.

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LIST OF ABBREVIATIONS

CDC	Centre for Disease Control
DALYs	Disability adjusted life years
GIT	Gastro-intestinal tract
GBD	Global Burden of Disease
GSS	Ghana Statistical Service
MDA	Mass Drug Administration
NTD	Neglected Tropical Disease
SSA	sub-Saharan Africa
STH	Soil-transmitted helminth
WHO	World Health Organization
FAO	Food and Agriculture Organization
PCR	Polymerase Chain Reaction
SD	Standard deviation
SPSS	Statistical Product and Service Solutions
RPM	Revolutions per minute
YLLs	Years of life lost
MRCP	Magnetic Resonance Cholangiopancreatography
OR	Odd ratio

ABSTRACT

Soil-transmitted helminths (STHs) continue to pose a substantial health risk to humans, particularly children, all over the world, with the majority of cases occurring in underdeveloped countries. This study, carried out from March to April 2021, investigated the impact of the COVID 19 pandemic on STH infections among primary school children in the Ho West and Afadjato South Districts in the Volta Region of Ghana using stool examination, microscopic techniques and administered questionnaire. The parasitological examination of 347 stool samples showed that 144 (41.5 %) were positive for STHs: hookworm (*Necator americanus and Ancylostoma duodenale*) (21.9%), *Trichuris trichiura* (10.4%) and *Ascaris lumbricoides* (9.2%). The risk of STH infection among females was observed to be higher compared to males (OR = 3.69; 95% CI =1.48-9.20; *p* = 0.005) In the Ho West district, school children who used blade to cut their nails are less likely at risk to helminth infection than those who bite their nails in Ho West district (OR= 0.26; CI = 0.93- 0.70; p= 0.008 but there was no significant association between potential risk factors and STHinfections in the Afadjato South District. More parents reported anthelminthic drug administration to their children before COVID-19 outbreak compared to during COVID-19 outbreak (χ^2 (df) =31.04(1), p <0.0001). Eighty-one of school children in both districts (84%) were positive for *Trichuris* infection, there was a significant difference between parent's response and *Trichuris* infection among those who administered anthelminthic drug before and during COVID-19 (p <0.0001). The high prevalence of STHs infections among primary school children calls for education on the proper hygiene habits and regular deworming exercise among residents in the study area.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

More than 1 billion people living in underdeveloped countries are estimated to be infected with at least one species of soil-transmitted helminths (STHs) globally (WHO, 2017). The common STHs that infect individuals are *Ascaris lumbricoides*, *Trichuris trichiura*, and hookworm species (*Necator americanus and Ancylostoma duodenale*) (WHO, 2018). *Ascaris lumbricoides* cases recorded are about 800 to 1000 million, 500 million reported *Trichuris trichiura* cases, 700 to 900 million hookworms cases reported (Wekesa *et al.*, 2014). Due to their high prevalence, chronic, and debilitating characteristics (Njenga *et al.*, 2011), these diseases presently are classified as Neglected Tropical Diseases (NTDs) by the World Health Organization (WHO, 2002). Heavy helminth infection affects around 300 million individuals globally, causing severe morbidity and mortality in the range of 10,000 to 135,000 persons each year (Lustigman *et al.*, 2012).

The helminthic parasites *N. americanus* and *A. duodenale* cause human hookworm infestation, with an estimated 1.3 billion cases worldwide and 65,000 deaths annually and is the most common chronic infection (Mehraj *et al.*, 2008). Hookworm infections are characterized by blood loss, iron deficiency and anaemia. Ascariasis is caused by *A. lumbricoides*, which is linked to a high risk of morbidity due to medical and surgical difficulties, as well as allergic reactions (Abera & Nibret, 2014). *A. lumbricoides* is projected to cause 1.471 billion cases of illness and 65,000 deaths worldwide. *Trichuris trichiura* lives in the colon and rectum and is as common as *Ascaris*. In people with a high infestation of *Trichuris*, the inflammatory alterations have been linked to rectal prolapse, chronic dysentery, and poor growth.

In children, STHs are not only considered to be a major cause of morbidity, but also, they are disproportionately impacted by STH, and afflicted children are typically underweight and anaemic as a result of the nutritional consequences. In Ghana, anaemia in children is a public health concern. Anaemia affects 76% of children in Ghana under age five, 73% aged between 2 to 10 years, and 63% of schoolchildren between ages 5 to 12 years (Egbi *et al.*, 2014). Intestinal helminthiasis is believed to aggravate pre-existent anaemia by lowering appetite and, as a result, food and iron consumption (Baidoo *et al.*, 2010; Bondevik *et al.*, 2000).

Epidemiologically, it is widely documented that while worms may be found in people of all age groups, children in rural regions have the highest rates of infections (Bethony *et al.*, 2006). Children behaviour is also a major risk factor for STHs infection. Children are typically highly energetic, playing unsupervised in soil and other things in their surroundings. Helminth control programs is an excellent target among school children and schools provide an ideal setting for control program execution since children are at a higher risk of helminth infection (Ojurongbe *et al.*, 2014).

Poor personal hygiene and environmental factors like pollution of environment and water bodies with human faeces as well as the use of night soil as fertilizer all contribute to the transmission of parasitic infection to people via the faecal-oral route (Gungoren *et al.*, 2007). Furthermore, they are mostly spread by contaminated fingernails and flies (Nyarango *et al.*, 2008). They are particularly common in areas with warm, humid weather, as well as poor sanitation and hygiene. Human health and the socioeconomic conditions of impacted populations are both affected by soil-transmitted helminths.

In endemic populations, STH infections tend to follow an "over scattered" pattern, with significant worm loads in a few people and little or absence of infection. Children with high worm load prefer to congregate in families or homes (Bethony *et al.*, 2006; Dold and Holland, 2011). Each of these nematode species has a direct life cycle and is soil-transmitted, meaning that the eggs or larvae responsible for transmission become infective after a required period of development in the soil. Due to the similarity in transmission and geographical spread of such helminths, many people get single, double, or triple infections. The maintenance of a continuous life cycle needs the presence of soil and eggs must embryonate in the soil to become infective in humid and wet conditions, and the embryonation duration varies per helminth species. The eggs of hookworm species, for example, can take up to 14 days to embryonate. *Trichuris trichiura* eggs need between 20 and 100 days to become viable, while *Ascaris lumbricoides* eggs take between 8 and 37 days. Suitable moisture and a warm temperature are required for larval growth in the soil, and climate is a major driver of infection transmission. Poverty, as well as insufficient water and sanitation, are significant factors. STH species are frequently co-endemic in such environments (Nguhiu *et al.*, 2009).

COVID-19 outbreak has implications for health systems and initiatives, mainly in inhabitants where neglected tropical diseases such as STH infections are endemic. In areas where soil-transmitted helminths are endemic, the COVID-19 pandemic will have an impact on health systems and initiatives. Neglected Tropical Diseases (NTDs), such as STH surveys, detection of active cases, and mass drug administration programs suspended, according to WHO advise, but diagnosis, treatment, and critical control of vector must carry on when practicable (WHO, 2020). The COVID-19 pandemic, with its severe public health impact, is without a doubt deserving attention. However, in current times, the diagnostic and therapeutic prerequisites for STH must not be overlooked, since many more people are living with them.

The government of Ghana's initiatives under the ministry of health has concentrated on deworming mainly in schools to decrease the morbidity related to STH infections for school children primarily living in endemic areas.

STH transmission in preschool children has been reduced as a result of deworming through school programs (Obala *et al.*, 2013). Improved watersanitation and hygiene appear to be a long-term sustainable control strategy for soil-transmittedhelminths. Despite efforts being made to increase hygiene and access to clean water, the WHOcontrol strategy for STH focuses on (MDA) to control and eventually eliminate STHs (Strunz*et al.*, 2014). The Ministry of Health's current deworming program is only for school-aged children; therefore, occupational children who are not in school may continue to be the bases of infection all over the year (Humphries *et al.*, 2011).

1.2 Problem and justification of the study

STH prevalence is about 30% in sub-Saharan Africa and is reported to be 50% in North-eastern part of Ghana (Humphries *et al.*, 2011). Heavy infections of STHs are linked to iron deficiency anaemia, stunted growth, cognitive impairment and malnourishment in school-aged children and immune-compromised individuals (Teklemariam *et al.*, 2014).

The current global priority is to prevent people from becoming infected with coronavirus and to treat those who have been infected. This has disrupted other health-related activities, such as NTD control and elimination programs, resulting in postponement of mass drug administration campaigns around the world. The COVID-19 pandemic has disrupted NTD programs in the year in which celebrating achievements towards 2020 goals should be achieved (WHO, 2020). The global economic, social, and health effects of the COVID-19 pandemic will be felt for a long time. In the case of STHs, it may result in reinfections as a result of delayed treatment. The effects of this disturbance, along with the epidemic, will reverberate for years. However, the administration of anthelmintic drugs and the impact of COVID-19 outbreak on these helminth infestations in school children and associated risk factors has not been reported in Ghana.

Helminth infestation such as STHs is regarded as neglected tropical disease that receives less study and funding worldwide, including Ghana. STHs have been linked to stunted development, malnutrition, and cognitive impairment in children in Sub-Saharan Africa, according to many studies (Ojha *et al.*, 2014). All of these factors have an impact on children's health and, as a result, their academic performance in school in the countries.

COVID-19 outbreak will place an extra burden on healthcare systems and programs in areas where soil-transmitted helminths are endemic. 87% of student population in the world is affected by the pandemic leading to closure of schools and over 1.5 billion students in 195 countries are affected by COVID-19 outbreak reported by UNESCO (2020b).

STH surveys and MDA activities has been suspended as advised by (WHO) while diagnosis, prompt treatment and control of vector should continue where necessary at areas where STHs are endemic (WHO, 2020). Diagnostic and treatments for STHs must not be overlooked during the outbreak, since a lot of lives are likely to be affected and lost through neglect. This study will investigate Soil-Transmitted Helminths infection in school children in this era of COVID-19 outbreak and the use of anthelmintic drug administration.

1.3 Objectives of the study

1.3.1 General objective:

To determine the impact of COVID-19 outbreak on the prevalence of Soil-Transmitted Helminths in school children the Ho West and Afadjato South of the Volta Region.

1.3.2 Specific objectives:

1. To determine the prevalence of STH infections during COVID-19 outbreak in Ho West and Afadjato South of the Volta Region.
2. To determine associated risk factors with STH among school children in (2) two districts inthe Volta Region.
3. To assess the impact of COVID-19 outbreak on the administration of anti-helminthic drugs to school children.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Global Distribution of Soil Transmitted Helminthiasis

In the Americas and high-income Asian countries, there has been a significant decrease in the prevalence of STH infections, this trend is until now to commence in sub-Saharan Africa (Chammartin *et al.*, 2013; De Silva *et al.*, 2003). Warm temperatures and moisture in the soil are critical for the development of infective larvae (Bethony *et al.*, 2006), which explains why tropical and sub-tropical locations have such a high prevalence. Inadequate water supply, sanitation, and poor hygiene are all major socioeconomic factors (Strunz *et al.*, 2014; Dunn *et al.*, 2016) that influence the spread of STH infections. Poverty is also a significant factor in STH infections (Ngui *et al.*, 2011; Ngui *et al.*, 2012).

STHs affect an estimated 4.5 billion people globally; 2 billion are infected, 135,000 people lose their lives annually (De Silva *et al.*, 2003). About a third of the world's populace is infected with roughly 20 major helminth diseases (Awasthi *et al.*, 2003). A total of 875 million school children are likely to be at risk of STH infection, with 30% of them being pre-schoolers and 70% being school children (Barry *et al.*, 2013). It is estimated that it has cost the globe at least 6.4 million (Disability Adjusted Life Years), with 1.7 million in sub-Saharan Africa, however, the disease burden has become increasingly concentrated in countries with low income as a result of this reduction, which is mostly concentrated in upper-middle-income countries (Stolk *et al.*, 2016). According to estimates, 117.9 million, 117.7 million, and 100.8 million persons in sub-Saharan Africa are infected with *A. lumbricoides*, hookworms, and *T. trichiura*, respectively (Pullan *et al.*, 2014). Togo and Sierra Leone have the most hookworm infections, whereas Gabon and Rwanda have the most *T. trichiura* and *A. lumbricoides* infections (Karagiannis-Voules *et al.*, 2015).

Hookworm prevalence in sub-Saharan Africa ranges from 30% to 50% (De Silva *et al.*, 2003); in the Ghana's middle belt the prevalence of helminth infection is quite comparable, at 45%. Infection with other helminths infections such as *Hymenolepis nana*, and *Taenia solium* is seen in 3% of people (Humphries *et al.*, 2011).

2.2 Conceptual framework of helminth infection

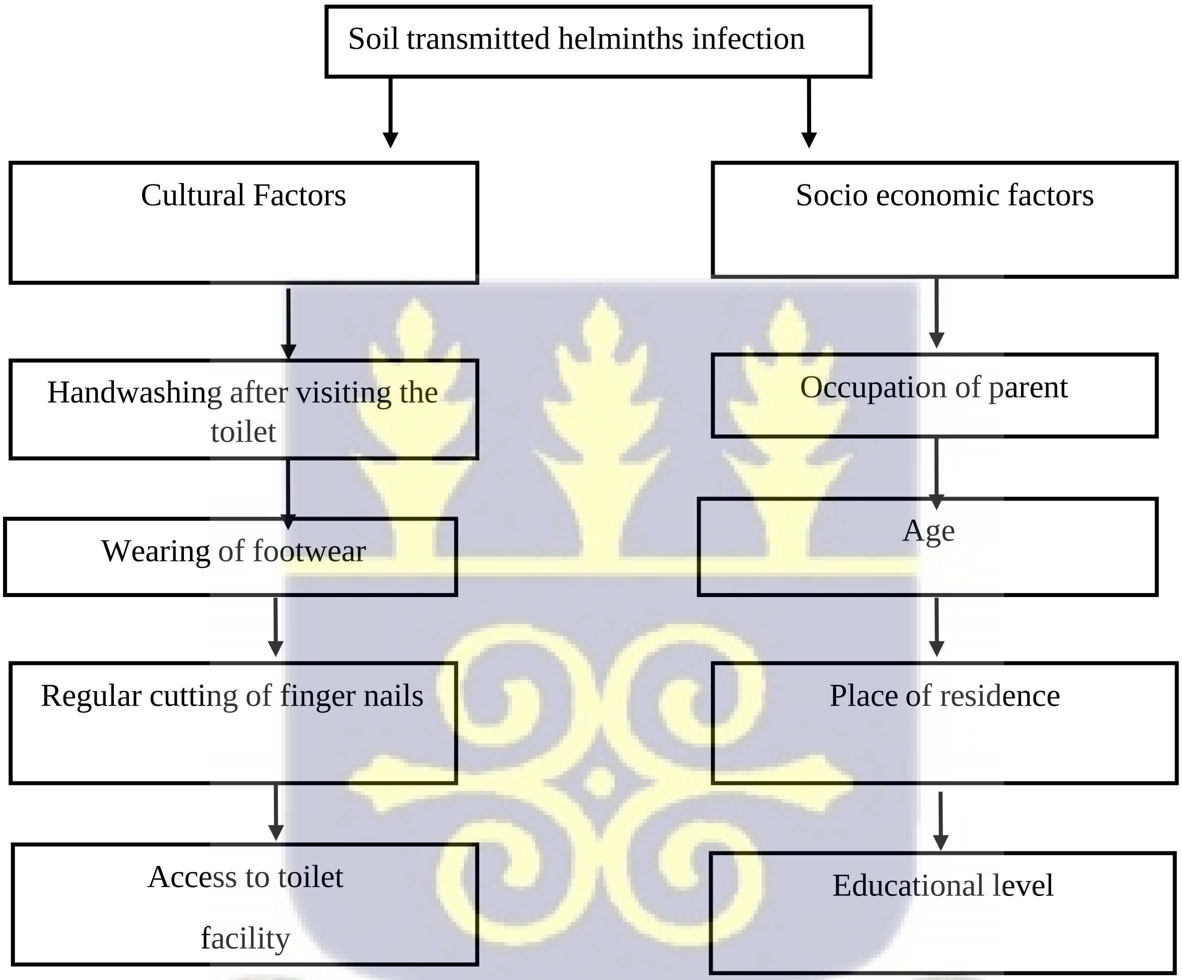

Figure 2.1: Conceptual framework of helminths infestation among school-going children.

The framework in Figure 1.1 tackles the different factors that might lead to an infection of STH among schoolchildren. Children frequently play in soil, which is home to these parasites. If fingernails are not correctly trimmed and handwashing is not done immediately after playing in the soil, children will be exposed to these soil-transmitted helminths. Children's residential location has more to do with their family's poverty, which might have an impact on their helminth infection because these parasites thrive in poor and congested environments. Also, because hookworm is most commonly spread by going barefooted, children who do so are at risk of contracting parasitic infection.

2.3 Helminths Classification

Helminths are invertebrates characterized by flat and elongated bodies. They are classified based of the place of habitat in the host organ, in the case of tapeworm and roundworms which reside in the intestine of the host (Mehraj V *et al.*, 2008). The Digenean Flukes (Trematode), Roundworms (Nematodes) and Tapeworms (Cestodes), are the three types of helminths which have humans as their primary host.

2.3.1 Nematodes

One of the major phyla harbouring parasites is Nemata. The general features of nematodes include bilateral symmetry and cylindrical form with tapering ends, lack of segmentation, circular coating, sexual dimorphism, and dioecy, however there are a few exceptions (Roberts and Janovy, 2009). Roundworms, often known as nematodes, may be divided into two categories. Tissue nematodes and intestine nematodes are two types of nematodes. *Enterobius vermicularis* (threadworm), *Ascaris lumbricoides* (roundworm), hookworm (*Ancylostoma duodenale* and *Necator americanus*) and *Trichuris trichiura* (whipworm) are among the intestinal nematodes (Cheesbrough, 2006). Nematodes are characterized by a smooth, spined, or ridged cuticle and a body cavity. Some species' adults are extremely long.

2.3.2 Trematodes

Trematodes (flukes) have small flat leaf-like bodies with no have a body cavity and are dorsoventrally flattened with bilateral symmetry. Most species are hermaphroditic, meaning they have both male and female reproductive organs with the exception of blood flukes. Before reaching the adult stage flukes go through several larval stages. Most flukes' infections in human are caused by Schistosoma species, liver flukes such as *Fasciola hepatica*.

2.3.3 Cestodes

Cestodes, often known as tapeworms, are flat, "segmented" worms that suck nutrition straight from the intestines of their hosts. A scolex, which adheres to the intestinal mucosa of its host, a neck, and strobila make up the tapeworm's body (Roberts and Janovy, 2009). Cestodes have an elongated, regular ribbon-like body with a distinct scolex and several segments. The absence of an alimentary canal is a distinguishing trait of adult tapeworms, which is fascinating given that all of these adult worms reside in the small intestine. According to estimates, the group has more over 20,000 described species, which is likely still a small percentage of the actual number of species (Caira and Littlewood, 2001).

2.4 Hookworms (*Ancylostoma duodenale* and *Necator americanus*)

Hookworm, like any parasitic worms, takes their name from the hook-like appendages that surround their mouths (Stephenson *et al.*, 2009). In 2015, over 428 million individuals were afflicted with hookworms, according to the Global Burden of Disease report (GBD, 2015). *Necator americanus* and *Ancylostoma duodenale* are the main hookworm species that infect people (Olaniran *et al.*, 2015). Adult *A. duodenale* worms are greyish white or pink in color, and have a slightly twisted head. They have two sets of teeth and a well-formed mouth. Females are longer and stouter than males, measuring about 1 centimeter by 0.5 millimeters. *N. americanus* has been discovered to be more common than *A. duodenale* around the world (Jiraanankul *et al.,* 2011). *N. americanus* is the most common hookworm in sub-Saharan Africa, Southeast Asia, and the Americas, while *A. duodenale* is found only in China and India. Anaemia is a common symptom of hookworm disease (Brooker *et al.,* 2004). Anaemia is dangerous especially in children and those that are who are also malnourished (Brooker *et al.,* 2004). Chronic infection in people who are not malnourished, can induce a drop in haemoglobin levels (Santos *et al.,* 2013). Eosinophilia is produced in large quantities by hookworm infections. However, adult parasite attaches itself to the small intestine's mucosa and submucosa, causing voracious blood sucking, is a major pathophysiology of hookworm infection. Delay in puberty, dry skin and oedema, are all symptoms of severe protein deficiency in children (Wang *et al.,* 2012).

Men have a higher prevalence of hookworm than females (Santos *et al.,* 2013), males participate in activities that endanger them at increased risk of infection.

2.4.1 Morphology of Hookworms

Hookworms are grouped together since they are both found all over the world and have overlapping geographic distributions; eggs of both species are similar and are not distinguishable under a microscope (Hall *et al.,* 2008). As a result, they have been referred to as hookworm in the past and treated as one and the same (WHO, 2002b). Although *Necator americanus* and *A. duodenale* have many physical similarities, *N. americanus* is generally smaller than *A. duodenale*, females measure around 1 centimeter and males measuring about 5 to 9 millimeters. In addition, the hook form in *N. americanus* is significantly more defined compared to *A. duodenale* (Markell *et al.,* 2006). Adult *Ancylostoma duodenale* worms are cylindrical, elongated, and thin. They are greyish-white in colour but when freshly passed out from the body, the worms appear reddish brown due to ingested blood. Hookworms get their name from the fact that their anterior end is somewhat twisted dorsally. *Ancylostoma duodenale* males and females are different and show sexual dimorphism. Females are bigger than males. The female has a narrower caudal end due to the existence of bursa copulatrix, whereas the male has a broader caudal end due to the presence of bursa copulatrix (copulatory bursa). The form, buccal capsule, and amle bursa are the main physical distinctions between the species. Anterior to the vulva is the vulva.

2.4.2 Life cycle of Hookworm

Ancylostoma duodenale and *Necator americanus* are the most common human hookworm infections (Brooker *et al.*, 2004), with the latter accounting for more than 85 percent of all hookworm infections (Tang *et al.*, 2014). The larvae develop in 1 to 2 days if the eggs are passed in the faeces and the circumstances are favourable, shade, moisture and warmth. After 5 to 10 days, rhabditiform larvae are releases and they develop in the faeces or dirt. They molt twice more before becoming infective third-stage larvae (IL3). The female hookworms mate and generate to about 10,000 eggs daily, and they depart the body of the host in the faeces which may pollute the soil and water if released. The egg hatches in the soil, releasing a larva that passes through many stages before infecting a new host. Hookworm enters a human through the skin, grows and develops, and prefers to reside in the duodenum. The larvae enter the skin when they come into touch with a human host (Logan, 2009) and later transported through the blood arteries and moves to the heart and subsequently to the lungs. They enter the pulmonary alveoli after skin penetration, move to the pharynx through the bronchial tree, and reside in the small intestines, where they mature into adults.

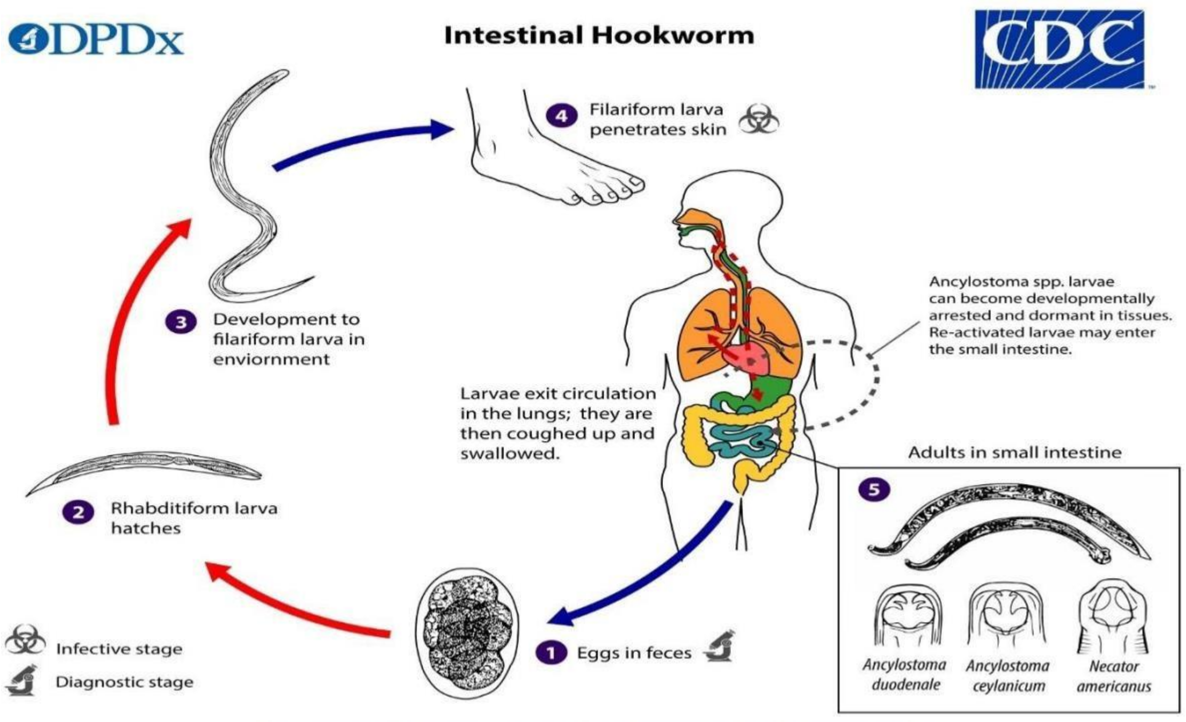

Figure 2.2: Life cycle of Hookworm (Source: www.cdc.gov)

2.4.3 Transmission of Hookworm

Since hookworm infection is spread by hookworm eggs contaminating the environment, risk of infections is likely to include poor hygiene (Traub *et al.*, 2004; Gunawardena *et al.*, 2005 and Asaolu and Ofoezie, 2003;), low level of education (Mihrshahi *et al.*, 2009; Liabsuetrakul *et al.*, 2009) and sanitation levels around the environment (Ensink *et al.*, 2005) which are the main drivers for the transmission of hookworm.

Hookworm transmission is highest along the world's coasts, infective third-stage larvae may readily move areas where temperature and moisture are ideal for larval survival in the soil (Mabaso *et al.*, 2003). Infectious larval stages (third stage larvae or L3) residing in the soil enter through the epidermis of the skin (Haas *et al.*, 2005) in the case of *N. americanus and A. duodenale* but ingestion of hookworm larvae only occurs in *A. duodenale* (Zeehaida *et al.*, 2011; Brooker *et al.*, 2004; Olsen *et al.*, 2009). Children are realtively active and they usually play in the soil with their bare hands, hence they are at a high risk of becoming infected with hookworm (Jiraanankul *et al.,* 2011). Hook worm larvae that have penetrated the human skin produce severe itching and irritation. Skin lesions in the form of papules and blisters develop as a result of this disease. Hookworm is more frequent in agricultural households, involving the extensive use of faeces as a night soil fertilizer, as well as among vegetable producers and farmers. Oral transmission can occur when food is consumed that has been inadequately cleaned or has been exposed to faecal contaminated soil. Transmission between a mother and her foetus or infant can also happen (rarely) through contaminated placental or mammary tissue.

2.4.4 Pathology associated with hookworm

Since adult worms are hematophagous, the most common complication of these infections are intestinal blood loss, which can result in iron deficiency anaemia. Although blood loss appears to be reduced in *N. americanus* infections, as predicted, 40 mature worms can decrease haemoglobin levels to below 11 g/dL (Bethony *et al.*, 2006). By causing intestinal bleeding, adult hookworms induce morbidity in their hosts (Hotez *et al.*, 2004). Matured hookworms consume a large proportion of blood, break erythrocytes, and destroy haemoglobin (Williamson *et al.*, 2003).

Hookworm infection can affect people of all ages, although children, adolescents and pregnant women are especially vulnerable to hookworm morbidity due to their high physiological needs for iron (Dobardzic *et al.*, 2002). Severe anaemia in pregnant women can put the mother's life, the foetus's life, and the neonate's life at jeopardy (Bethony *et al.*, 2006; Brooker *et al.*, 2008; Gyorkos *et al.*, 2011a; Brentlinger *et al.*, 2003). Since hookworms cannot reproduce in humans, patients with huge numbers of adult parasites have the highest hookworm morbidity.

Quantitative faecal egg counts are commonly used to estimate the severity of hookworm infection.

2.4.5 Clinical Manifestation of hookworm

A mild hookworm infection typically causes no symptoms, but a moderate or severe hookworm load can cause tiredness, recurring stomach discomfort, and iron deficiency anaemia. Repeated skin contact with hookworm L3 can produce a cutaneous condition known as "ground itch" (Brooker *et al.*, 2004), which can cause sleep disruption due to severe itching (Jackson *et al.*, 2006). Clinical characteristics are thought to correspond to the parasite's life cycle and the severity of infection (Strickland, 2000).

The first symptom is a burning, stringing, or grinding itch feeling caused by larvae penetrating the skin. Pruritis and a papulo vascular rash appear, which lasts for 1 to 2 weeks. Hypoproteinemia and anasarca severe widespread edema (Bethony *et al.*, 2006; Hotez *et al.*, 2004), stunted development, and causes a delay in puberty are other significant clinical signs of these diseases.

2.4.6 Diagnosis of hookworm

Hookworm infection and diagnosis are mostly overlooked because patients are usually presented with non-specific gastrointestinal complaints. Since the eggs of both *Ancylostoma* and *Necator* appear identical, they are grown in the laboratory to allow larvae to hatch out in order to identify the genus (Markell *et al.*, 2006). PCR tests are usually used to diagnose hookworm in the faeces using a molecular method since eggs of hookworm are often indistinguishable from other parasite eggs (Yong *et al.*, 2007; Gasser *et al.*, 2009).

The larvae of hookworm eggs would hatch out if stool samples containing the eggs are left for more than a day under favourable conditions (Markell *et al*, 2006).

The Kato-Katz thick smear, ether concentration method, sodium acetate-acetic acid-formalin solution, FLOTAC technique, and PCR are all used in the identification of hookworm eggs. The development of DNA-based methods for infection detection, precise hookworm identification, and the study of genetic variability within hookworm populations has been a focus in recent research (Gasser *et al.*, 2009).

2.5 *Ascaris lumbricoides*

Ascaris lumbricoides, is morphologically similar to earthworm. The global prevalence of ascariasis is estimated to be more than 1.3 billion people with over 250 million people suffering from related morbidity (Crompton and Savioli, 2007). Years of life lost (YLLs) owing to *A. lumbricoides* infections alone total 204,111 throughout the world (Lozano *et al.* 2012). The most often afflicted children are those aged 2 to 10 years, with the frequency decreasing beyond the age of 15. It has direct lifecycle and it's the most important parasite of human and animals (Urquhart *et al.*, 2003).

Ascaris lumbricoides, is in the family Ascarididae and is closely linked to the *Ascaris suum* (swine parasite) (Roberts and Janovy, 2009a). It is found all throughout the world, and it is common in the tropical zones of Asia particularly India and China and in Africa. Adult worms generally live in the jejunum, although they are also found throughout the small intestine, especially in high numbers (Bethony *et al.*, 2006).

2.5.1 Morphology of *Ascaris lumbricoides*

Males of *Ascaris lumbricoides* measure 2–4 mm in diameter and 15–31 cm in length (Roberts et al., 2009). The male's tail is bluntly pointed and his posterior end is curved ventrally. Females have a width of 3–6 mm and a length of 20–49 cm (Roberts and Janovy, 2009). The vulva is found around the front end, makes up about a third of its total length. Fertilized eggs have a thick shell and are round to oval in form, measuring 44-74 micrometres long and 30-45 micrometres broad, but unfertilized eggs are 87-93 micrometres long and 43 micrometres wide (Roberts *et al.*, 2009).

2.5.2 Life cycle of *Ascaris lumbricoides*

Humans become infected with *Ascaris* through a faecal-oral pathway and larvae grow in the parenteral tissue of the host when infective eggs are ingested and hatched (Dold and Holland, 2011). Infection occurs when human consumes contaminated food or drink that has fertilized eggs. The eggs are digested in the small intestine by digestive juices, releasing the already developed larvae (Mwinzi *et al.*, 2012). The larva enters the lungs, grows, and travels down the bronchial tree, causing throat pain. About 240,000 eggs are laid by a female *Ascaris* worm daily, which are then transmitted through the faeces. In the external environment, the larva grows in the egg and hatches after egg is consumed by a host. After 19 days to several weeks' viable eggs become infective depending on environmental circumstances such as optimal warm and moisture in the soil (Ziegelbauer *et al.*, 2012). After swallowing infective eggs, larvae hatch, penetrate intestinal mucosa, goes through lungs via the portal and systemic circulation. The larvae enter the lungs through the air sacs and migrate to the trachea, where they are coughed up and ingested. Adult female must wait 2 to 3 months after ingesting the infective eggs before oviposition occurs. Adult worms have a lifespan of one to two years. (CDC, 2015).

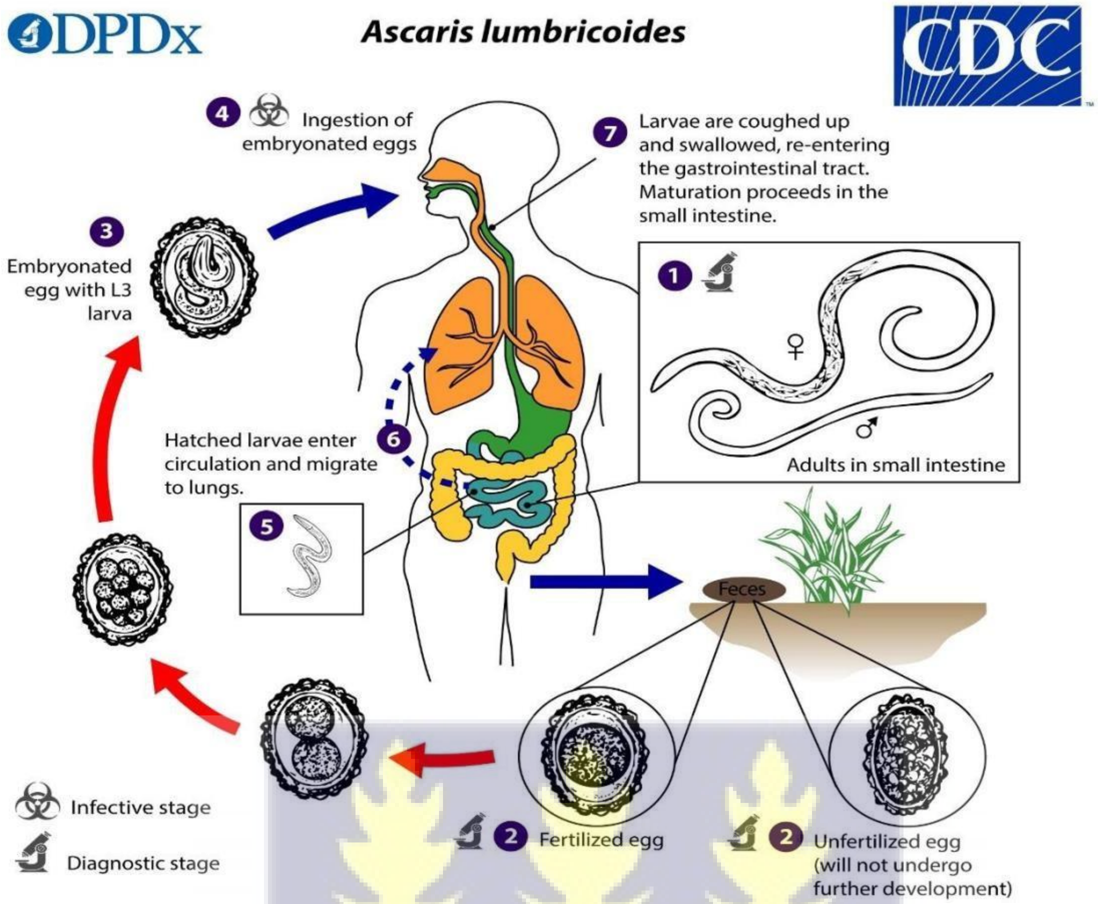

Figure 2.3: Life cycle of *Ascaris lumbricoides* (Source: www.cdc.gov)

2.5.3 Transmission of *Ascaris lumbricoides*

The most common mode of transmission of *Ascaris* is the faecal-oral route. Infected people's faeces contain eggs, which must be exposed to a warm, wet soil environment to growand become infectious. Embryonation of freshly discharged eggs takes 9-40 days before they become infective. Contaminated hands can transport eggs from the soil/water to the mouth, or eggs can be eaten with meals (uncooked vegetables and unwashed fruits).

2.5.4 Pathology associated with *A. lumbricoides*

Ascariasis pathology is diverse. However, it may be broadly divided into organ damage and host-sensitive responses caused by migratory larvae, as well as the adult worm's huge size and activity. During larval development, *A. lumbricoides* produces significant host-tissue inflammation. Adult worms in the small intestine cause little or no symptoms, depending on the host's health history, infection severity, and duration (OLorcain & Holland, 2000). *A. lumbricoides* infections is linked to severe malnutrition, particularly in children (Bethony *et al.*, 2006; Stephenson *et al.*, 2011).

2.5.5 Clinical Manifestation of *Ascaris lumbricoides*

Ascariasis is a parasitic infection that mostly affects children, causing malnutrition, stunted growth and difficulties in learning (Hagel and Giusti, 2010). In more than 85% of instances, infections are asymptomatic, especially in persons with a modest worm load. Symptoms vary in intensity depending on the worm load leading to difficulties breathing and fever accompanied by diarrhoea, abdominal pain and abdominal swelling (Dold and Holland, 2011). Children's cognitive development may be harmed by moderate and severe illnesses (Jukes *et al.*, 2007). Severe stomach discomfort, tiredness, vomiting, weight loss, worms in stool are all symptoms. *Ascaris* worms in large numbers in the small intestine induce abdominal distension and discomfort, which can progress to partial or total blockage, intestinal perforation, and deadly peritonitis (Farrar *et al.*, 2013). Adult worms cause chronic ascariasis symptoms (which appear six to eight weeks after egg intake and last for up to 18 months following infection). Abdominal pain, anorexia, nausea, vomiting, and diarrhoea are examples of non-specific symptoms.

2.5.6 Diagnosis of *Ascaris lumbricoides*

Eggs in the faeces are diagnostic methods for identifying *Ascaris* eggs. The numerous eggs are detected in the direct cover glass mount. If the results of the direct test are negative, the concentration technique may be used (Cheesbrough, 2006). For imaging Ascaris worms in the biliary tree, abdominal ultrasonography is the method of choice (Sherman & Weber, 2005). During the inspection, worms may be solitary, numerous, in bundles, and moving. When abdominal ultrasonography is not possible, as it is in certain pregnant women, magnetic resonance cholangiopancreatography (MRCP) provides an option (Arya *et al.*, 2005).

2.6 *Trichuris trichiura*

Trichuris trichiura is a round worm which infects the large intestines of humans and causes trichuriasis. The term whipworm is due to the worm's body form, which is whip-like with wider "handles" towards its back (Hayes *et al.*, 2010). It spreads by the faecal-oral route, with a high incidence in places with tropical temperatures and inadequate sanitation (Bethony *et al.*, 2006). *Trichuris trichiura* is found all over the world, with an estimated 500 million human infections (Hunter and Mckay, 2004). It is, however, mostly tropical, particularly in Asia, South America and Africa (Hunter and Mckay, 2004). In less developed countries, *Trichuris trichiura* is more frequent. *Trichuris trichiura* affects nearly a quarter of the world's population (Donkor, 2009). Adult worms can be seen in the large intestine, particularly in the cecum. *Trichuris*, unlike *Ascaris*, lives on the intestinal mucosa rather than in the intestinal lumen. In most cases, their lifespan is 1.5 to 2 years (Bethony *et al.*, 2006); nevertheless, infections have been reported to extend up to 8 years (Bogitsh *et al.*, 2012; Shiff, 2007).

2.6.1 Morphology of *Trichuris trichiura*

Matured female worms measures 35–50 mm and relatively longer than males, with males measuring about 30–45 mm. Females have a rounded posterior end and its blunt, with males having a coiled posterior end. Eggs measure 25-35µm in width, 50-70µm in length and are barrel-shaped and brown they also have two distinct mucoid polar plugs (CDC, 2015). Eggs contain an un-segmented ovum when it leaves the human hosts. The adult worms attach themselves to the walls of the host’s intestines and due to that they are rarely recovered from the stool (Garcia, 2007; Heelan, 2004).

2.6.2 Life cycle of *Trichuris trichiura*

In a single day, female *T. trichiura* produces 4,000–10,000 unembryonated eggs. Eggs are realease in the soil from human faeces, embryonate in 2–3 weeks, and then enter the “infectious” stage. Newly discharged eggs require sometime to mature in the soil (2 - 4 weeks at 22 ^{o} C in humid soil) before embryonating and producing a first-stage larva (L1), which is the infective stage for humans (Bogitsh *et al.*, 2012; Nejsum *et al.*, 2012; Hotez *et al.*, 2003). The eggs are transmitted by contaminated hands or drinking water contaminated. The cycle history of an egg begins when it is consumed in any of these ways. The eggs hatch in the small intestine after being ingested by soil-contaminated hands or food, releasing larvae that develops into adults. The caecum and ascending colon are where the adult worms reside. Copulation occurs between the sexes, and eggs produced by the female emerge in the faeces of the host 70 to 90 days after the eggs are consumed. *Trichuris* eggs can last up to 6 years in the soil under ideal conditions, but desiccation and high temperatures are harmful (Asaolu *et al.*, 2002c).

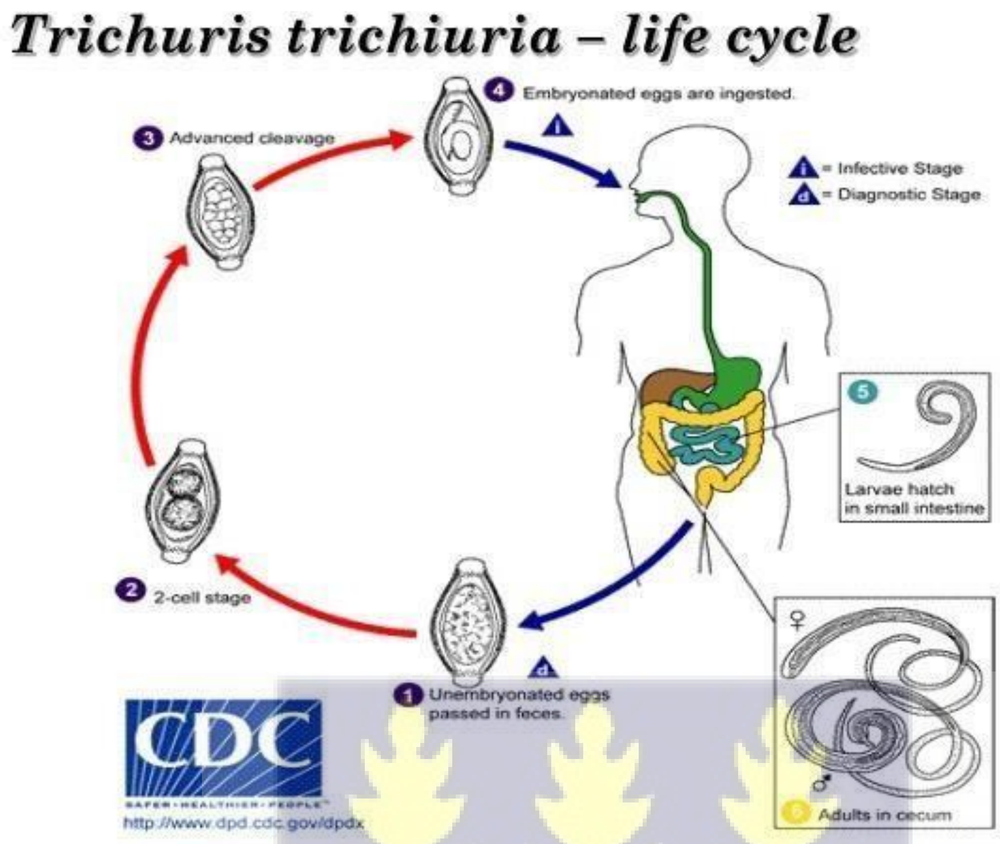

Figure 2.4: Life cycle of *Trichuris trichiuria* (Source: www.cdc.gov)

2.6.3 Transmission *of Trichuris trichiura*

Infectious eggs from contaminated soils, hands, food, or water are consumed and spread through ingestion. In order for eggs to become infective, they must spend at least 15 to 30 days in warm, moist soil. Anthropogenic activities, as well as wind, water, and insects, spread eggs in the environment (houseflies can act as mechanical vectors).

2.6.4 Pathology associated with *Trichuris trichiura*

The majority of morbidity symptoms are caused by the host's inflammatory response to the worms' hold on the mucosa's epithelial tunnels (Stephenson *et al.*, 2011). Trichuris dysentery syndrome caused by heavy and moderate infection of *T. trichiura* worm can result in diarrhoea, rectal bleeding and anaemia but light *T. trichiura* infections are mostly asymptomatic (WHO, 2002).

2.6.5 Clinical Manifestation of *Trichuris trichiura*

The most severe form of trichuriasis is Trichuris dysentery syndrome (TDS) which primarily affects children, however it has been documented in adults as well (Hotez *et al.,* 2003; Khuroo, 2010). Many mild infections are asymptomatic at first, but serious symptoms such as persistent bloody diarrhoea with copious mucus, loss of weight anaemia, and rectal prolapse in children can occur (Albonico *et al.,* 2008; Stephenson *et al.,* 2000). Several epidemiological investigations have demonstrated high worm load can result in morbidity, even at modest infection intensities (Bieri, 2013).

2.6.6 Diagnosis of *Trichuris trichiura*

Microscopically detecting whipworm eggs in a stool sample is the usual approach for diagnosing the presence of whipworm. A concentration method is employed since eggs in mild infections eggs might be difficult to identify. Clinically, trichuriasis is difficult to distinguish from infections with other intestinal worms. When *Trichuris trichiura* eggs are found in faeces, trichuriasis can be diagnosed (Levinson, 2008). Unembryonated eggs with bipolar plugs and a smooth shell will seem barrel-shaped.

2.7 Prevention and Control of intestinal parasites

For long-term prevention and control of STH and other enteric infection, access to water, sanitation, and hygiene (WASH) is essential (Campbell *et al.,* 2014; Strunz *et al.,* 2014).

The most essential component in maintaining helminth control programs in schools is the support of the children's parents and families, as well as the community at large. Significant support for these programs will develop with the help of additional proponents (ministries of health, education, and non-governmental organizations) (Montresor *et al.*, 2002). For and effective and stable management and control of STH, understanding the mode of transmission and risk factors functioning in endemic populations are significant (Lustigman *et al.*, 2012; Weaver *et al.*, 2010). Preventive treatment has been found to significantly reduce STHinfection morbidity (Strunz *et al.*, 2014), although re-infection is common in endemic regions(Jia *et al.*, 2012). It is predicted that treating only school children in high prevalence populationscan avoid 70% of the overall burden caused by soil transmitted helminths (Asaolu and Ofoezie,2003).

Periodic deworming with benzimidazoles (albendazole and mebendazole) to uninfected at-risk persons on a regular basis, supported by health education, is the most cost-effective technique for decreasing the morbidity associated with STH infections. (WHO, 2002; Albonico *et al.*, 2006; Savioli *et al.*, 2002).

The health benefits of deworming have gotten a lot of attention, but the research isn't always reliable. Regular deworming has minimal effect on children, according to a recent longitudinal research from India (Awasthi *et al.*, 2013). Taylor Robinson and co-workers (2007) did a meta-analysis to assess the efficacy of deworming on child development and school performance, and found that study data is insufficient to suggest deworming medicines in targeted populations (Taylor-Robinson *et al.*, 2007). Health and hygiene promotion reduces transmission and reinfection through improving health education and generating awareness (Aiello *et al.*, 2008; Asaolu and Ofoezie, 2003; Ekpo *et al.*, 2008; Fewtrell *et al.*, 2005; WHO, 2006).

Periodic deworming, on the other hand, is seen as a less complicated and inexpensive approach to STH control (Albonico *et al.*, 2008; Molyneux *et al.*, 2005; Crompton *et al.*, 2003; Montresor *et al.*, 2011; WHO, 2012). Clean water supply, food hygiene, improved sanitation and health education, in combination with treatment of a sick person, reduce the transmission of parasite in the long run. (Ngonjo *et al.*, 2012).

In a research to investigate the prevalence of STH in Cameroon (Richardson *et al.*, 2011), revealed that intestinal parasite infections were lower in Bawa village (7.1%) due to improved sanitation than in Nloh village (15.7%), which had poor sanitation. Access to potable water reduces STH infections mostly mainly to increased hygiene; for example, handwashing is linked to decreased ascariasis transmission (Bartram and Cairncross, 2010; Fung and Cairncross, 2009). Since faecal contamination is the most common mode of STH transmission, maintaining excellent hygiene and washing hands with soap on a regular basis is suggested as a preventative strategy (Montresor *et al.*, 2011). Handwashing before eating and after defecating is linked to a reduced risk of *A. lumbricoides* infections of 0.38 (95% CI 0.26–0.55) and 0.45 (95% CI 0.35–0.58), respectively (Strunz *et al.*, 2014). Handwashing was also found to be a protective factor against STH infections in a handful of cross-sectional investigations done with Ethiopian students (Alemayehu, 2008; Alemu *et al.*, 2011). Diarrhoea can be avoided to a significant degree by disrupting the faecal-oral transmission pathway by sanitary treatments such as improved personal cleanliness, waste disposal, and proper food preparation (Kümmerle, 2014).

2.8 Risk Factors for Soil Transmitted Helminths

Personal cleanliness, use of toilet facilities, wearing shoes, handwashing and consuming raw food are behavioural risk factors. Farming and other occupations that have a lot of soil contact raise the risk of STHs infection (Balen *et al.*, 2011). In endemic areas, the primary cause of

STH transmission is improper disposal of human excreta (Strunz *et al.*, 2014). Higher education and socioeconomic status, on the other hand, have been proven to be favourable indicators of enhanced cleanliness, which protects against STH infections (Ohta and Waikagul, 2007). In Kenya, *Ascaris spp* infections were linked to a drop in the weight of six-month-old children (LaBeaud *et al.*, 2015). Poverty, poor sanitation, large densities of domestic animals (Hayes *et al.*, 2003), large family sizes (Traub *et al.*, 2004, 2009), children under age 15 especially males are mostly at risk for STH infections (Mohammed Mahdy *et al.*, 2008). The availability and use of toilets is another risk factor. Cysts are usaully washed down to water bodies or transported by flies that serves as mechanical and contaminate food or water supplies when individuals defecate in the open (Cheesebrough, 2005).

Children have a considerably higher frequency of diarrhoea and higher egg counts for STH than adults, according to systematic studies, as a result, children stool offers a larger health risk than adult stool (Crompton *et al.*, 2003). In Ghana, 19% of children under the age of five are stunted, 11% are underweight, and 5% are wasting (GSS, 2015).

In Ghana, rural regions account for 22% of stunting, whereas urban areas account for 15%. Similarly, underweight children in rural regions are 13% more as compared to those in the urban areas of about 9% (GSS, 2015). Improper faeces disposal might account for the spread of helminths infections.

2.9 Sanitation and STH infections

Improved sanitation aims to limit transmission by decreasing pollution in the soil and water. Sanitation is the only permanent solution for eradicating STH infections, but it must reach a large proportion of the population to be successful (Hotez *et al.*, 2006).

In areas where open defecation is practiced, the concentration of STHs eggs in soil can be quite high. The eggs of STH are excreted in the faeces. When faeces are disposed of in such a way that they come into touch with soil, the ova find a suitable habitat in which to develop and mature into infective forms. Anecdotal data suggests that open defecation is linked to a greater risk of hookworm infection (Schmidlin *et al.*, 2013). In Kenya, it was discovered that toilet facilities located outside homes had a substantially greater incidence of STH infection than those located within the household premises (Worrell *et al.*, 2013). Sanitation is linked to a lower risk of STH infection and is an important component of integrated STH management efforts (Bartram and Cairncross, 2010; Ziegelbauer *et al.;* 2012 Mara *et al.*, 2010). A comprehensive analysis published in 2012, Zeigelbauer *et al.*, discovered that the provision of sanitary facilities provided substantial protection against STH with an odds ratio of 0.46-0.58. Periodic deworming will not provide a sustained decrease in transmission without a change in defecation behaviours (Hotez *et al.*, 2006). The reuse of wastewater and sludge has been linked to an increased risk of infection. In endemic regions, wastewater can hold about 3500 eggs per litre (Kamizoulis, 2008; Mara and Sleigh, 2010).

2.10 Hygiene and regular handwashing

Handwashing using soap at suitable times, such as before food preparation, after coming into contact with animals, after urinating and visiting the toilet and after touch with rubbish, is the most essential component of personal hygiene. Fewtrell, Prüss-Üstün, and Bos 2007 reported that it is quite usual for a student in Africa to be infected with STHs which is prevalent in children a result of inadequate hand washing with soap and water. Evidence shows that cleanliness plays an essential part in the prevention of parasite illnesses caused by soil-transmitted helminths (Bieri, 2013; Kümmerle, 2014). Hand washing with soap and water after being implemented in primary schools, show a 30% reduction in diarrhoea incidence (Ejemot -Nwadiaro *et al.*, 2009).

2.11 Morbidities associated with soil-transmitted helminthiasis

Regardless of near-ubiquity of STH worldwide, it is difficult to estimate the real impact of these infections due to the paucity of study on the morbidities associated with them (Utzinger and de Savigny 2006; Nagpal *et al.*, 2013). The number of worms a host harbors is significantly associated with morbidity, and persons with multiparasitism are likely to have higher morbidities than people with single species infections (Brooker, 2010). *Ascaris* infection can lead to vitamin A deficiency, acute intestinal blockage (which kills over 10,000 people each year), and hepatobiliary and pancreatic ascariasis (Hotez *et al.*, 2003). Anaemia, protein malnutrition, low birth weight and death in infants, are all linked to heavy hookworm infection (Loukas *et al.,* 2016). Stunting (low height-for-age), wasting (low body mass index-for-age), and anaemia are frequent markers of malnutrition utilized for such assessments in areas where food resources are short (FAO 2012). Helminths have been shown to have a negative impact on the health of humans (Hailegebriel, 2018; Njaanake *et al.*, 2015) by impairing nutritional digestion and absorption, resulting in undernutrition, anaemia and stunting growth (Casmo *et al.,* 2014; Kinung'hi *et al.*, 2017; Hailegebriel, 2018; Njaanake *et al.*, 2015). It has also been proven that helminth infection is associated with a decrease in the host's cognitive skills (Kvalsvig *et al.*, 2002). As previously stated, morbidity induced by STH causes absenteeism in children leading to poor academic performance and, poor pregnancy outcomes and low productivity at workplace in adults (Guyatt, 2000).

2.12 Educational background associated STH infection

Nematian *et al.* (2010), reported that mothers' educational level lowers the parasite infection rate in children. Low incidence has been recorded among educated and skilled employees, as well as those with a good quality of life (Ugbomoiko and Ofoezie, 2007). Enlightenment via public health education is thought to be able to help individuals alter or at least adjust some of their habits and beliefs for the better (Nock *et al.*, 2007).

2.13 Climate, Water, Season and STH infection

Climate events such as high temperatures and rain have an influence on the infective forms of STH's soil habitat and, as a result, on their prevalence.

Transmission of worm is promoted in their pre-parasitic stages mostly in wet seasons in an environment that favours transmission. This contrasts with dry season circumstances, which kills infective larvae deposited on the soil, lowering transmission dynamics (Weaver *et al.*, 2010). Although *Necator americanus* is the most common hookworm globally (Hotez *et al.*, 2004), a change in temperature may ultimately favour *Ancylostoma duodenale* since it can withstand developmental arrest as larvae in human tissues as a means to survive extreme conditions (Hotez *et al.*, 2004, Brooker *et al.*, 2006). Increased temperature shortens the time to embryonation and infectivity in *Ascaris* and *Trichuris*, although it is linked with the mortality of the ova above critical levels. It's been hypothesized that overall rainfall and its seasonal distribution in a given location might help explain observed infection patterns: wetter environments are generally linked with higher transmission of all three main soil transmitted helminth diseases (Brooker and Michael, 2000).

2.14 Effects of STH in preschool children

A. lumbricoides, *T. trichiura*, and hookworm are the most frequent species, which infect children and cause substantial physical, cognitive, and economic impairments (Brooker *et al.*, 2006). Children are the most vulnerable for STH infections. The immune system of the younger generation is less developed, and they have higher dietary needs (Brooker *et al.*, 2006). The presence of 26 mature *Ascaris lumbricoides* worms in a kid has been demonstrated to deplete a child's entire protein supply to about one tenth (Bundy and Drake, 2004).

Nutritional problems and STH infections are commonly seen together in impoverished nations, according to several research. Stunting was found to be prevalent in 48 percent to 56 percent of children in Ghana, Tanzania, Vietnam, India, and Indonesia, whereas underweight was found to be prevalent in 34 percent to 62 percent of children (Christiana *et al.*, 2014). Accordingto epidemiological statistics, infection starts around age one and two, and the severity and prevalence increases with age (Horiuchi, 2013). Hookworm infection that is severe and persistent during a child's development has ramifications on their cognitive performance and eventually, their academics (Jinabhai *et al.*, 2001).

2.15 Diagnostic Method in Parasitological Laboratory

The choice of a diagnostic method for STH infections influenced by its sensitivity, affordability and simplicity (WHO, 2002). Diagnosis of soil-transmitted helminths can be done by finding worm eggs or adult worms in faeces (Akujobi *et al.*, 2005). The accuracy of various faeces testing procedures is highly dependent on adequate sample collection and storage practices.

2.15. 1 Concentration methods

Sedimentation or flotation procedures can be employed for concentration, with the latter being the most commonly utilized for diagnosis (Knopp *et al.*, 2011a; Mahon *et al.*, 2007). In sedimentation, eggs of the parasite form a sink at the bottom of the liquid, for flotation eggs of the parasite suspends in a liquid with a high specific density making them buoyant and float to the surface. High sensitivity is associated with concentration techniques. It enables the identification of eggs and organisms in low-infection situations that would otherwise be missed by other approaches, particularly the direct wet method. The concentration approach has the added benefit of permitting transportation and storage of faeces once they have been preserved in formalin (Oguama and Ekwunife, 2007). Concentration by floatation uses a liquid suspending medium that is heavier than the parasite eggs allowing them to float and be collected from the film (Cheesbrough, 2005).

2.15.2 Kato-Katz technique.

This technique is currently a WHO-recommended "Gold standard" for identifying STH and Schistosoma eggs, particularly when egg quantification is needed. In Kato Katz, large particles are eliminated by sieving faeces through a mesh. Sample is moved onto a slide through a template with a hole that contains a defined amount of faecal material (for example, a 9 mm hole on a 1 mm thick template holds roughly 50 mg of faeces). The template is removed, remaining sample is covered with cellophane soaked in glycerol-methylene blue solution. To clean the faeces, slides should be maintained at room temperature or in a 40°C incubator (except for hookworms). Despite the broad acceptance of Kato-Katz, several writers have pointed out that using the technique as suggested by WHO results in limited sensitivity in cases of mild infections, especially after deworming. Despite the fact that Kato–Katz is cheap and straightforward to use, samples with low infection intensity makes detection of several STH challenging (Garcia*et al.,* 2018).

2.15.3 Baermann technique

The Baermann technique is centred on the idea that active larvae will move out of a faecal specimen put on a wire mesh coated with many layers of gauze (Garcia, 2001). This is the most commonly used in parasitological field surveys because it does not require any complex laboratory materials and culturing or immunological procedures takes a lesser time (Knopp *et al.*, 2008; Olsen *et al.*, 2009).

2.15.4 Molecular diagnosis

These high-tech methods are specific and sensitive, allowing for the differentiation of parasite species that are morphologically identical, however, in underdeveloped nations, they are frequently too expensive (Hotez *et al.*, 2006).

Molecular diagnostic methods like (PCR) with primers generated from various genetic markers are helpful. The method is useful for distinguishing between two species that are morphologically identical, such as *Ancylostoma duodenale* and *Necator americanus* (de Gruijter *et al.*, 2005). Ayana *et al.*, (2019) examined preservation techniques and four DNA extraction for molecular identification and quantification of STH in faeces and discovered substantial variations in DNA recovery. However, since PCR techniques are based on group specific gene or species gene sequence, they are more particular than morphological approaches. However, sensitivity was low due to the delay in DNA extraction if the samples were retained in the preservatives, making it acceptable for analysing samples with preservatives in a distant laboratory collected from remote areas (Ayana *et al.*, 2019). PCR techniques have proved to be more sensitive as compared to microscopy-based methods in identifying parasite eggs in low quantities, notwithstanding their limitations (Oliveira *et al.*, 2010; Guy *et al.*, 2003).

2.16 COVID - 19 impact on STHs Programmes

The COVID-19 pandemic was caused by the SARS-CoV-2 Virus (Coronaviridae). The virus spreadquickly after the first cases were discovered in Wuhan, China, on November 17, 2019, and was designated a pandemic on March 11, 2020. The WHO suggested that MDAs, detection of active cases, and surveys in and around the community for STHs be postponed until April 2020 (WHO, 2020). The decision to stop administering PCs during COVID 19 is not a firm one. Delays in Mass Drug Administration (MDA) rounds would result in a higher number of infections in communities, since both existing infections and opportunistic infections will go untreated. This means that some of the benefits (prevalence decreases) made in prior rounds of MDA will be lost. Mathematical modelling, conducted by the NTD Modelling Consortium, can give quantitative insights into how delays may affect NTD programs (Gyapong *et al.*, 2018).

COVID-19 is expected to make the lives of millions of people living with STHs even more precarious, and the chances of maintaining STH prevention, control, and elimination gains slim, with disease resurgences expected since money and human resources will be diverted to combat the pandemic (Ehrenberg *et al.*, 2020).

(Bradbury *et al.*, 2020) emphasized the possibility of adverse interactions between COVID-19 and helminths infection severity in areas where helminth infections are endemic, as well as the fact that helminth infection-related changes in gut microbiota appear to have systemic immunomodulatory effects. As noted by Huang *et al.*, 2021 on resource tracking for STHs, measuring the economic impact, cost, and cost-effectiveness of integrated STHs programs would assist decision-making in nations seeking to improve domestic finance for sustainable STH management and eradication. Efforts to eradicate soil-transmitted infection during the COVID 19 pandemic has been disturbed.

Ghana, as a tropical country, bears a double burden. For example, the management of COVID-19, which has made no major progress to date, along with the prevalence of NTDs, will continue to be a public-health issue. Efforts to minimize the spread of COVID-19 globally and locally has a direct influence on the preventive and control programs for soil-transmitted diseases (STDs), which are one of the neglected tropical diseases. Although a stop in STD prevention treatment would only have a temporary impact on progress toward the WHO 2030 objective, programs must be resumed as quickly as feasible to avoid morbidity (Malizia *et al.*, 2021). Ehrenberg *et al.*, 2020 pointed out relevant strategies that can support the control of STH, focusing on the virus's zoonotic origins and demonstrating how collaborations can be used to minimise STH infections during the pandemic. Given the mitigation techniques recommended by national NTD programs as preventative measures (increased handwashing and physical separation measures), the start of NTD programs will offer little danger of viral spread. Several of the strategies used preventing and controlling STHs, such as regular handwashing, sanitation, hygiene, and health education, are also being used to prevent COVID-19 spread. However, if COVID-19 is reduced following a corresponding decrease in STHs infections, the suggested strategies and long-term modifications have proven inadequate.

CHAPTER THREE

3.0 MATERIALS AND METHOD

3.1 Study design

A cross-sectional study was conducted among school children in Afadjato South District and Ho West District in Ghana from March 2021 to April 2021. Stool samples were collected from children in primary one to JHS three in the (2) two districts and were examined for helminth eggs. Socio-demographic characteristics of the school children and their parents, including age, sex, risk factors for parasitic infections were recorded using structured questionnaires. Their status with respect to whether they have taken anti helminths drugs before and during COVID-19 was also documented.

3.2 Study area

This study was conducted in the Ho West and Afadjato South Districts of the Volta Region of Ghana. The Volta region is one of the sixteen regions in Ghana and is located between latitudes 50◦ 45‟N and 80◦ 45‟N in the South-eastern part of the country, bounded by Togo on the east and Lake Volta on the west.

Afadjato South District and Ho West District are close in proximity and have common boundaries. Afadjato South District is one of Ghana's twenty-five (25) Municipalities and Districts. It was formed in 2012 when the Hohoe Municipal District was dissolved. Golokwati is the district's administrative capital. The District is bordered to the north by Hohoe Municipal, to the west by Kpando Municipal, to the east by the Republic of Togo, and to the south by Ho West District and South Dayi District.

The district is located in Ghana's wet semi-equatorial climatic zone, with annual rainfall ranging from 1,016 mm to 1,210 mm. The area experiences an average of four to five months of dry season. Temperatures are hot all year, ranging from 26°C in the coolest months to around 32 °C in the hottest months. The Ho West

District is bounded on the south by the Adaklu District, on the north by the Afadjato South District, on the east by the Ho Municipality and the Republic of Togo, and on the west by the South Dayi District. It is located between latitudes 6.33° 32" N and 6.93° 63" N and longitudes 0.17° 45" E and 0.53° 39" E with a total land area of 1,002.79 square kilometers and a population density of 94.3 based on a population of 94,600 people (Ghana Statistical Service, 2014). The Ho West district is also constrained by two major vegetation zones: damp deciduous forest, which frequently shrouds the area's hills, and savannah woodland (Ghana Statistical Service, 2014).

Figure 3.1: Study area showing selected areas for the study

3.3 Ethical approval

Permission was obtained from the Ghana Education Service, the Afadjato South District, and the HoWest District. Before visiting the schools in this study, the district public health authorities, district education authorities, and the school administrators were educated on the aims and benefits of the research.

The study focused on school-aged children from 6 to 17 years of age, covering from basic one to JHS three. Children younger than 12 years consented verbally and children between 12-17 years of age signed their assent forms and were informed about the objectives and benefits of the research. Each student was issued a distinctive ID number when they registered. All parasitological and survey data was coded and treated confidentially.

3.4 Inclusion criteria

Participant of the research included school children within Afadjato South District and Ho West District and their guardians who agreed and signed the consent forms.

3.5 Exclusion criteria

These included school children who did not want to participate in the research for one or two reasons and those whose parents or guardians did not want them to participate.

3.6 Sample size determination and Sampling Technique

Children attending primary schools in Afadjato South District and Ho West District were selected systematically through random sampling. Study subjects were randomly sampled, first student in the school's register was chosen, followed by the third student in the register for each class from Primary to JHS. The sample size was estimated by taking the prevalence as 50 %.Sample size was calculated using the formula (Naing *et al.*, 2007).

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

Where, n= sample size

Z= 95% confidence interval (1.96)

P = prevalence of disease (50%)

d= precision (0.05)

Thus, n= $(1.96)^2$ (.5) (1-0.5)/ $(0.05)^2$

Giving a total of 384

But only 347 samples were collected

3.7 Data and stool collection

347 stool samples in total were collected from school children in the (2) two districts. In total seven (7) schools were sampled. Four (4) from Afadjato south and three (3) from Ho West.

A structuredquestionnaire that probed into sociodemographic and environmental factors were collected through interviews. Each participant was given an already labelled (ID) stool collection container, applicator sticks, and instructions on how to collect and hand over the sample and were advised to bring the stool samples the next morning. Filled containers with stool sampleswere collected from 7 am and 9 am and were later transported to the Jim Bourton Memorial Agricultural SHS for helminths identification the same day.

3.8 Study adherence

School children that took part in the study, completed the study questionnaire and provided stool samples were 347. Parents that also completed the study questionnaire were 318, but only 270 school children had corresponding stool sample and completed questionnaire with corresponding parent's questionnaire.

3.9 Laboratory Procedure

Formalin-Ethyl Acetate Sedimentation Concentration was used to examine fresh human faecal samples. One gram of stool sample was mixed with 10 mL of 10% formalin solution into a beaker and homogenized until all faecal material was suspended and sieved using a molded plastic strainer with pores not greater than 0.5mm x 0.5mm whose sieve opening size allow parasite eggs to pass through the strainer into a 15ml conical centrifuge tube while excess faecal debris was retained. 10% formalin was added through the strainer to bring the volume to 15 ml. The mixture was centrifuged at 3000 revolutions per minute for 3 minutes. The upper layerwas thrown out, and the sediment was re-suspended with 10 ml of a 10% formalin solution andwas thoroughly vortexed using a wooden applicator. After adding 4 mL of ethyl acetate, the solution was vigorously shaken for 30 seconds before being centrifuged at 3000 revolutions per minute for 3 minutes. The upper layers of the supernatant comprising ethyl-acetate, debris,and formalin were decanted after the debris block at the top of the tube was released. A cotton-tipped applicator was used to remove any remaining material from the tube's side.

A few drops of normal saline was added to suspend the residue. On a clean slide, one drop of the suspension was placed and covered with a cover slip. For more details, the slide was examined under a compound light microscope with an x10 objective and then switched to high power.

3.10 Identification of Helminths Eggs

A parasitological atlas was used in the identification of eggs and larvae in stool samples (Cheesbrough, 2006). Identification was based on morphological characteristics of parasitic articles as follows. Hookworm eggs had grey cells or were dark-brown in colour and measured between 50 and 60m in length. *T. Trichiura* eggs measured about 50-53µm by 22-23µm in size were barrel-shaped plug at each pole. Eggs of *Ascaris* were oval in shape.

3.11 Data Processing

The questionnaires that were given to school children in order to collect data were coded.

Identification of eggs present or absent were presented in tables. Questionnaires, and all other data were entered into the Microsoft Excel and imported into SPSS for analysis.

3.12 Data Analysis

Descriptive statistics was used to calculate for the data of 347 children. School children with infections for hookworm, *Ascaris lumbricoides* and *Trichuris trichiura*, were calculated using cumulative frequencies. A Chi-square test was performed to compare districts and schools with intestinal parasitic infections. P values < 0.05 were considered statistically significant.

Logistic regression with 95% confidence interval (CI) was used to determine the association between potential risk factors and infections.

CHAPTER FOUR

4.0 DESCRIPTION OF RESULTS

4.1 Study population

347 school-age children in total were examined for soil-transmitted helminths in seven schools in the Afadjato South District and Ho West District between March and April 2021. 318 parents were also interviewed from the ages range between 30 to 50 years. Majority of parents' interviewed were farmers as shown in Table 4.1

Table 4.1: Sociodemographic characteristics of parents and school children

Parameter	Frequency	Percentage (%)
CHILDREN (N=347)		
Sex		
Male	171	49
Female	176	51
Age group		
6 -8	15	4.3
9 -11	60	17.3
12 -14	174	50.1
15-17	98	28.3
PARENTS (N=318)		
Sex		
Male	147	46
Female	171	54
Age group		
30- 35	82	25.8
36-40	96	30.2
41-45	58	18.2
46-50	82	25.8
Occupation		
Farmer	179	56
Trader	121	38
Civil Servant	18	6

Table 4.2: Comparison of (STH) infections in school-aged pupils of Afadjato South and Ho West district during COVID-19 outbreak

Parasites	Ho West N=120 (%)	Afadjato South N=227 (%)	Total N=347 (%)	χ^2 (df); p-value**
Ascaris lumbricoides				
*NPS	105 (87.5)	210 (92.5)	315 (90.8)	
Positive cases	15 (12.5)	17 (7.5)	32 (9.2)	2.35 (1); 0.125
Hookworm				
*NPS	88 (73.3)	183 (80.6)	271 (78.1)	
Positive cases	32 (26.7)	44 (19.4)	76 (21.9)	2.43 (1); 0.119
Trichuris trichiura				
*NPS	109 (90.8)	202 (89.0)	311 (89.6)	
Positive cases	11 (9.2)	25 (11.0)	36 (10.4)	0.29 (1); 0.592

*NPS: no parasite seen; **p-values of parasite prevalence comparisons

Table 4.2 shows the relationship between prevalence of parasites and districts. The overall prevalence of *Ascaris* was 9.2%. In Ho West and Afadjato South district the prevalence of *Ascaris* was 12.5% and 7.5% respectively. However, the prevalence of *Ascaris* was not significantly related to the districts (p>0.125) as shown in Table 4.2.

The overall prevalence of hookworm was 21.9%. The prevalence of hookworm was 26.7% and 19.4% in Ho West and Afadjato South districts respectively. However, the prevalence of hookworm was not significantly related to the districts (p>0.119) as shown in Table 4.2. The overall prevalence of *Trichuris* was 10.4%. The prevalence of *Trichuris* was 9.2% and 11.0% in Ho West and Afadjato South districts respectively. However, the prevalence of *Trichuris* was not significantly related to the districts (p>0.592) as shown in Table 4.2.

Figure 4.1 shows the prevalence of each infection. Hookworm had the highest overall prevalence of 21.9%, followed by *Trichuris* (10.4%). *Ascaris* had the least overall prevalence (9.2%) among the sampled school children in the Volta Region.

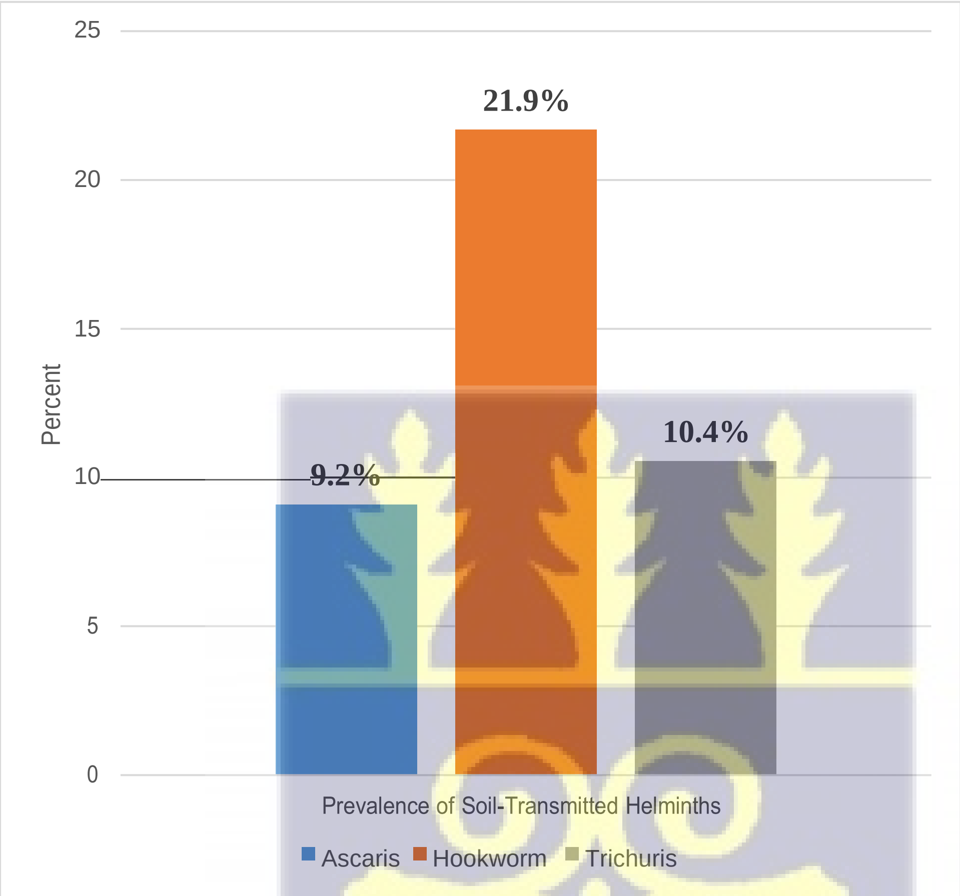

Figure 4.1: Prevalence of soil transmitted helminths among school children in the Ho West and Afadjato South districts.

Table 4.3 presents the prevalence among age groups and sex of school children. Prevalence of STH infections was higher in females (45.4%) than males (37.4%). Also, Hookworm infection was higher within sex groups, followed by *Trichuris* and *Ascaris*. Establishing the significance level or the p-value at 5% (0.05). For all there STH infections there was no significant difference (P>0.05). With respect to age groups, children between 6-8 years old recorded the highest prevalence of soil-transmitted helminths infections, while those between 12-14 years old recorded the least prevalence of all three STH infection of 38.5%. Prevalence among all age groups insignificant (P>0.05).

Table 4.3: Prevalence of soil-transmitted helminths infections among age and sex of school children

Parameter	**Measurement (n)**	***Ascaris* (%)**	**Hookworm (%)**	***Trichuris* (%)**
Sex	Male (171)	16 (9.4)	30 (17.5)	18 (10.5)
	Female (176)	16 (9.1)	46 (26.1)	18 (10.2)
	P-value	**0.932**	**0.053**	**0.927**
Age	6-8 (15)	3 (0.9)	4 (1.2)	1 (0.3)
	9-11 (60)	10 (2.9)	13 (3.7)	6 (1.7)
	12-14 (174)	13 (3.7)	36 (10.4)	18 (5.2)
	15-17 (98)	6 (1.7)	23 (6.6)	11 (3.2)
	P-value	**0.050**	**0.921**	**0.959**

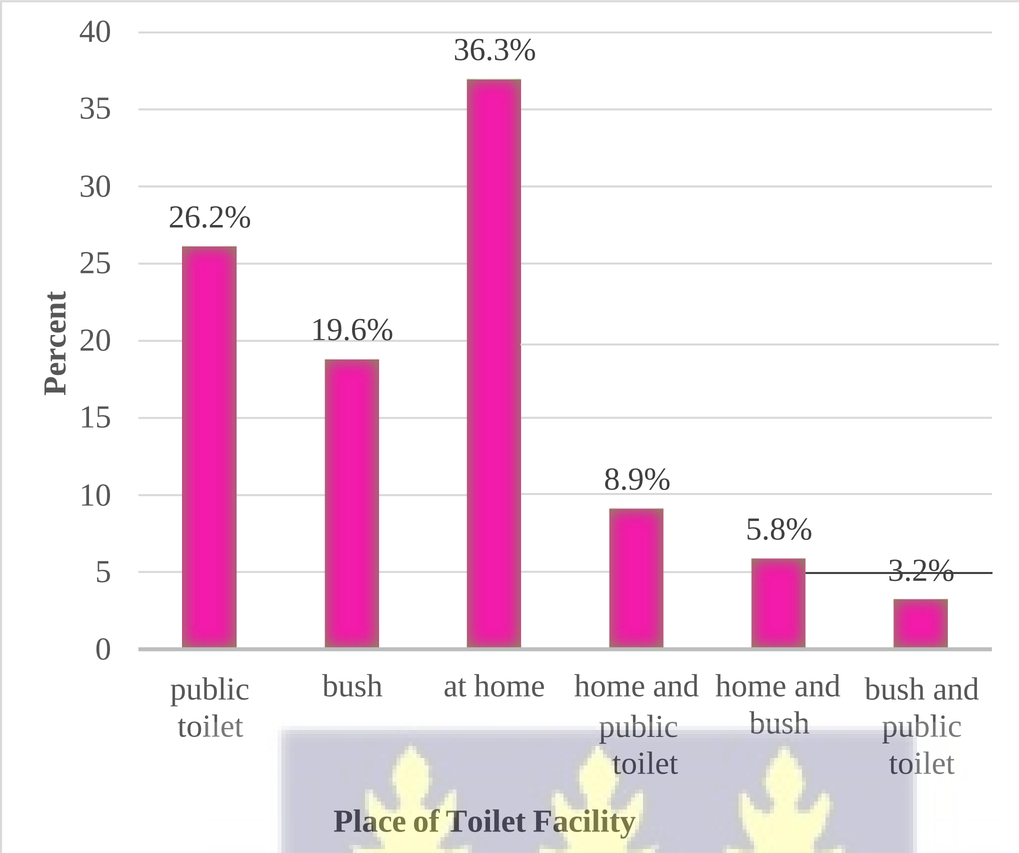

Figure 4.2: Respondents' place of going to toilet

About 36.3% of school children sample for the study go to toilet at home (figure 4.2). Those who go to public toilets were 26.2% while 19.6% go to the bush. The rest of the respondents rotate or combine these three places.

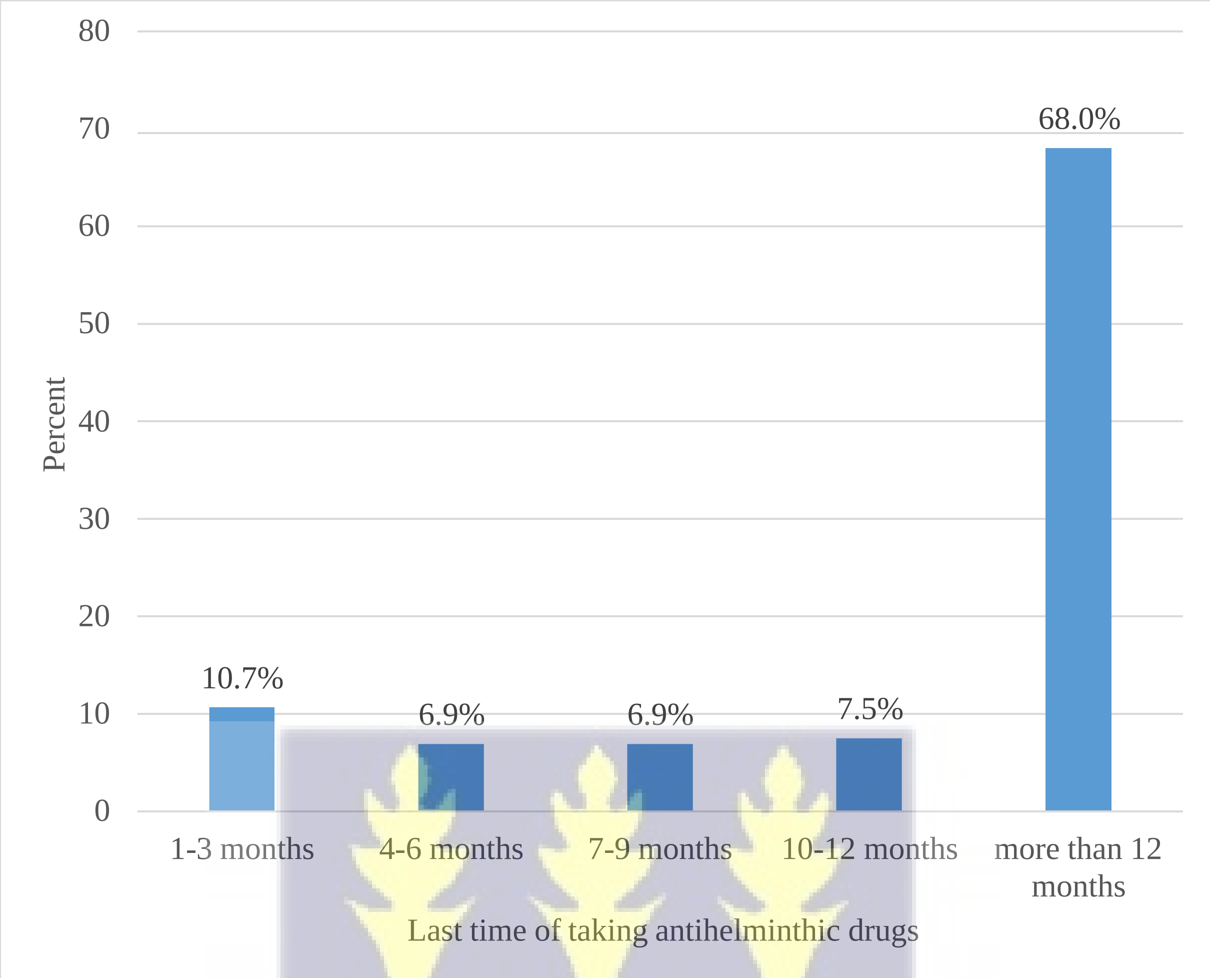

Figure 4.3: Respondents' last time of taking anthelminthic drugs

Figure 4.3 also presents the last time school children took anthelmintic drugs. Majority of the sampled school children (68.0%), the last time they took the anthelminthic drug was about a year (12 months) or more. Only 10.7% of the children had taken an anthelminthic drug in the last three months. The rest are distributed between 4 -11 months.

Table 4.4: Prevalence and univariate analysis of factors associated with STH infection by simple logistic regression for Ho West District

Parameters	N=120	STH Infections (n*)%	OR (95% CI)	p-value**
Sex				
Male	66	20 (39.2)	1	
Female	54	31(60.8)	3.69(1.48-9.20)	0.005**
Age category				
6 – 8	5	3 (5.9)	1	
9 – 11	27	7 (13.7)	0.18(0.16-1.97)	0.158
12-14	60	26 (51.0)	0.57(0.58-5.50)	0.624
15-17	28	15 (29.4)	1.23(0.13-13.48)	0.864
Handwashing before food				
Yes	68	29 (56.9)	1	
No	23	9 (17.6)	0.44(0.11-1.78)	0.252
Sometimes	29	13(25.5)	0.96(0.31-2.92)	0.940
Has toilet at home				
Yes	75	29 (56.9)	1	
No	45	22(43.1)	1.36(0.56-3.32)	0.501
Always wear shoes				
Yes	63	26 (51.0)	1	
No	57	25(49.0)	1.67(0.64-4.36)	0.292
Has taken anthelminthic drugs				
Yes	60	25 (49.0)	1	
No	60	26 (51.0)	0.71(0.27-1.87)	0.493
Handwashing after toilet				
Yes	56	26 (51.0)	1	
No	17	6 (11.8)	0.47(0.11-1.97)	0.302
Sometimes	47	19(37.2)	1.18(0.44-3.19)	0.733
Handwashing method				
Yes	31	14(27.5)	1	
No	89	37(72.5)	0.62(0.22-1.73)	0.361
Nail cutting behaviour				
Bite nails	45	25 (49.0)	1	
Use blade	75	26 (51.0)	0.26(0.09-0.70)	0.008**

n* Number of hookworm positive cases in each category

**Indicate variables with P < 0.05.

Table 4.5: Prevalence and univariate analysis of factors associated with STH infection by simple logistic regression for Afadjato South

Parameters	N=227	STH Infections (n*)%	OR (95% CI)	p-value**
Sex				
Male	105	35 (44.5)	1	
Female	112	43 (55.1)	0.99(0.54-1.79)	0.998
Age category				
6 – 8	10	4 (5.1)	1	
9 – 11	33	16 (20.5)	1.50(0.35-6.41)	0.586
12-14	114	35(44.9)	0.75(0.19-2.92)	0.682
15-17	70	23(29.5)	0.82(0.21-3.28)	0.782
Handwashing before food				
Yes	138	48 (61.5)	1	
No	9	3 (3.8)	0.92(0.18- 4.66)	0.919
Sometimes	80	27(34.6)	1.00(0.53-1.90)	0.996
Has toilet at home				
Yes	120	40 (51.3)	1	
No	107	38 (48.7)	1.12(0.61-2.05)	0.725
Always wear shoes				
Yes	111	38 (48.7)	1	
No	116	40 (51.3)	0.99(0.56-1.74)	0.960
Has taken anthelminthic drugs				
Yes	167	56 (71.8)	1	
No	60	22 (28.2)	1.14(0.60-2.30)	0.688
Handwashing after toilet				
Yes	151	53 (67.9)	1	
No	11	5 (6.4)	1.45(0.53-5.95)	0.606
Sometimes	65	20 (25.6)	0.83(0.41-1.65)	0.588
Handwashing method				
Yes	37	11(14.1)	1	
No	190	67(85.9)	1.22(0.55-2.71)	0.632
Nail cutting behavior				
Bite nails	66	24 (30.8)	1	
Use blade	161	54 (69.2)	0.84(0.44-1.60)	0.585

n* Number of hookworm positive cases in each category

**Indicate variables with P < 0.05.

The risk of STH infection among females was observed to be higher compared to males (OR = 3.69; 95% CI =1.48-9.20; *p* = 0.005) school children in the Ho West district, Volta Region as shown in Table 4.4. Also nail cutting behaviour in the Ho West district was significant (OR= 0.26; CI = 0.93-0.70; p= 0.008). The association of STH infection among other variables in both districts are shown in Tables 4.4 and 4.5.

Administration of Anthelminthic drugs and prevalence of soil-transmitted helminth infections.

The results reveal that 179 respondents, representing (56%) had administered anthelminthic drug to their children before COVID-19, whereas 139 respondents (44%) did not administer anthelminthic drugs to their children before COVID-19. Prevalence among respondents who gave dewormers to their children during COVID-19 period were computed. The result (Table 4.6) shows that out of the 318 parents, 208 did not administered anthelmintic drugs to their children. However, the responses of parents who did not administered anthelminthic drugs during COVID-19 and before COVID-19 were highly statistically significantly p<0.0001 as shown in Table 4.5. Also, the responses of parents who administered anthelminthic drugs before COVID-19 and those who during COVID-19 were statistically significantly p<0.0001.

Table 4.6: Administration of anti-helminthic drugs to school children before and during COVID-19 outbreak (*responses of parents*)

Anti-helminthic drugs administration	Frequency of responses (percentage) N=318	Difference in percentage frequency (95%CI)	χ^2 (df); p-value
Before Covid-19			
Administered	179 (56)	22 (14.32 - 29.32)	31.04(1), <0.0001*
Not administered	139 (44)		
During Covid-19			
Administered	109 (34)		
Not administered	208 (66)	22 (14.32 - 29.32)	31.04(1), <0.0001**

*p-value of parent responses comparing anti-helminthic drugs administered and not administered (**) before and during Covid-19 outbreak.

Table 4.7: Administration of anti-helminthic drugs and soil-transmitted helminth (STH) infections in school-aged pupils during COVID-19 outbreak

	Dewormer during COVID-19			
Characteristics	**Not Administered N=174 (%)**	**Administered N=96 (%)**	**% difference of cases**	**χ^2 (df); p-value****
Ascaris lumbricoides				
*NPS	158 (90.80)	90 (93.75)		
Positive cases	16 (9.20)	6 (6.25)	0.72	0.72 (1); 0.397
Hookworm				
*NPS	129 (74.14)	75 (78.13)		
Positive cases	45 (25.86)	21 (21.88)	0.53	0.53 (1); 0.466
Trichuris trichiura				
*NPS	159 (91.38)	15 (15.63)		
Positive cases	15 (8.62)	81(84.38)	75.76	154.39 (1); <0.0001**

*NPS: no parasite seen; **p-values of parasite prevalence comparisons

Table 4.7 shows the relationship between prevalence of parasites and the use of anthelminthic drug during COVID-19 based on parental responses. A greater proportion of school children in both districts (84%) were positive for *Trichuris* infection and there was a significant difference between parent's response and *Trichuris* infection between those administer anthelminthic drug before and during COVID-19 (Table 4.7).

CHAPTER FIVE

5.0 DISCUSSION

The overall prevalence of the three soil-transmitted helminth (STH) infections was (41.5 %) in the study area according to the research findings, and was higher than previously reported prevalence (12.5%) among school children in the Volta Region (Orish *et al.,* 2017) before COVID-19 outbreak. Similar studies in parts of Ethiopia reported lower prevalence of STH infections ranging from 0.47% (Tefera *et al.*, 2015), 12.6% (Fikreslasie, *et al.,* 2017) to a prevalence of 20.9% (Shiferaw, & Mengistu, 2015).

Hookworm (21.9%) was the predominant of the three STHs, followed by *T. trichuris* (10.40%) and *A. lumbricoides* (9.20%) in the study. *A. lumbricoides* and *T. trichiura* infection are the most common causes of STH infections worldwide, and then hookworm infection (Pullan *et al.,* 2010). In the current study, however, the prevalence of hookworm infection was much higher than that of *A. lumbricoides* and *T. trichiura* infections. Additionally, hookworm larvae in the soil from development of larvae to infective stage and is mostly between 3 to 11 days, in thecase of *A. lumbricoides* larval development to infective stage takes about 28-84 days and 10- 30 days for *T. trichiura*, which increases their chances of surviving and finding a new host (Clements *et al.*, 2010). STHs transmission highly depends on environmental factors (climate, soil structure) which influences chances of parasite survival and the level of contact between vulnerable host contaminated soil (Sturrock *et al.*,2017). In both Ho West and Afadjato South most of the schools visited had no toilet facilities and even water.

STH endemic areas are grouped into (high transmission areas, where there is 50% greater prevalence; moderate transmission, where prevalence is between 20%-50%; and low transmission, where prevalence is less than 20%) according to MDA (WHO, 2002).

The study area falls within the moderate transmission category, necessitating annual deworming. The high prevalence rate of STH infections (41.5%) in school students could be attributable to the suspension of STH surveys, identification of active cases, and (MDA) programs according to WHO.

The COVID-19 pandemic has underlined the vital significance of hand hygiene in disease prevention and control on a genuinely global scale. In the era of COVID-19 pandemic people were advised to observe social distancing and proper hygiene practices amidst the pandemic. Handwashing with soap and water accompanied with the regular intake of anthelminthic drug has always been one of most preventive ways for STHs infection (Prüss-Ustün *et al.*, 2014).

Frequent handwashing can reduce the spread of STH infection and provide cost-effective practice to reduce STH associated disease burden. Despite regular handwashing with soap and water during COVID-19 the prevalence of STHs infections was higher. This could be attributed to improper handwashing by school children or handwashing without soap.

Frequent deworming in schools also plays a significant role for STH transmission. The main goal of frequent deworming in schools is to reduce STH morbidity and this goal can be achieved by administering preventive chemotherapy adequately (Montresor *et al.*, 2012). The prevalence of STHs in similar studies reports a significant reduction of overall STHs prevalence with the use of anthelminthic drug (Abera *et al.*, 2004; Ngonjo *et al.*, 2012). There was a reduction in infection rate of helminths following the use of anthelminthic drugs (Gelaw *et al.*, 2013).

The goal of the WHO is to control STH and minimise the infection rate of heavy and moderate infections to less than 1%. This could mean the end of STH infections as a public health issue, as well as the end of transmission (WHO, 2012). Preventive chemotherapy is a critical technique for achieving this goal. For effective control of STH, WHO recommended that in high endemic areas, deworming programs and treatments should be period be every six months (WHO, 2012).

The data obtained on the participants on the use of anthelmintic drugs shows a continuous decrease in the number of persons who were administered anthelmintic drugs during COVID-19 outbreak as compared to the number who were administered anthelmintic drugs before COVID-19 outbreak. There was a significant difference for parent's response on the administration of anthelmintic drug and *Trichuris* infection between those that administer anthelminthic drug before and during COVID-19 (Table 4.7). However, there was no significant difference for hookworm and *Ascaris*.

With respect to COVID-19 and the administration of anthelmintic drugs only 96 (35.56%) administered anthelmintic drugs to their children during COVID-19 and 38 (34.86%) were infected with at least one of the three STHs. Contrary to that, 174 (64.44%) did not administer anthelmintic drugs during COVID-19 to their children and 71 (65.14) were infected with at least one of the three STHs. Out of the 174 who did not administer anthelminthic drugs to their children during COVID-19 outbreak, reasons such as anthelminthic drugs being expensive (85;

48.85%), scarce (41; 23.56%) and lack of knowledge of anthelmintic drugs/dewormers (48; 27.59 %).

Re-infection after each MDA therapy round is reported to be common (Zacharia *et al.*, 2020). Majority of the sampled school children (68.0%) took anthelminthic drug 12 months or more before the study. Only 10.7% of the children had taken an anthelminthic drug three months before the study. This period of time is sufficient for re-infection in populations with lack of potable water, poor hygiene and inadequate sanitation facilities are present on a daily basis. STH re-infection can occur within six months, with prevalence rebounding to above 50% of its previous level (Jia *et al.*, 2012). Three important measures such as the usage of anthelminthic drug, health education and sanitation, are required for eradication and long-term management of STHs endemic areas (Tchuem Tchuenté 2011).

In addition, prevalence varied with sex. Hookworm infection was higher in females (46; 26.1 %) than in males (30; 17.5 %), but there was no significance (Table 4.2). Hookworm infection has been linked to walking barefooted as a major risk factor for transmitting STHs (Alemu *et al.*, 2011; Bleakley, 2007). In Plateau State, prevalence of hookworm infection was higher in females as compared males (Odebunmi *et al.* 2007). Contrary to the findings of Ibidapo and Okwa (2008) who reported higher hookworm infection in males than in females in Nigeria. Findings of this study corroborate with prior study that found no significant differences in the prevalence of STH according to gender (Taheri *et al.*, 2011).

This study looked at the relationship between potential risk factors and the prevalence of STH infections in the Ho West and Afadjato South district. Age, study sites (districts), and sex were significant predicators of STHs. Only sex and nail cutting behaviour were those that indicated significant associations with STH infections in the Ho West district. There was no significant association in the Afadjato South district. The risk of STH infection among females was observed to be higher compared to males (OR = 3.69; 95% CI =1.48-9.20; p = 0.005) school children in the Ho West district. Also nail cutting behaviour in the Ho West district was significant (OR= 0.26; CI = 0.93-0.70; p= 0.008). People who use blade to cut their nails are at a low risk of helminth infections that does who bite their nails and was statistically significant.

Children between 6-8 years old had the highest prevalence of soil-transmitted helminths infections while those between 12-14 years old had the least prevalence of all three STH infection of 38.5%. Younger children have little knowledge about hygiene hence have a poorer hygiene as compared to adults (Mamandou *et al.*, 2010). Ibrahim (2012) carried out a study in Iraq in children aged 11 years and below. Low immunity against pathogens leading to less resistance to diseases, poor hygiene, overcrowding and low socioeconomic status resulted in a prevalence rate of 30.8%. Gradual increase in prevalence of infection with age for STH infections gives an indication of the exposure patterns of the children considering that they are becoming more active with age. Health education on transmission of STH and encouraging children to wear shoe might help in prevention and control of hookworm infections.

The socio-economic status of parents is another important potential risk factor that may predispose pupils to STH infections. The result indicates that the majority of the parents (56%) were farmers. The rest of the parent respondents were traders (38%) or civil servants (6%). Children whose parents were farmers had the highest infection rate since farmer's farm around their houses and keep animals. The majority of farmers use animal waste as manure, which can increase soil contamination with STH ova, leading to an increase in infection prevalence. This finding is congruent with the findings of Kirwan *et al.* (2009), who discovered that children of farmers have a larger burden of *A. lumbricoides than* children of businesspeople or professionals. Augusto *et al.* (2009) reported that farmers had a higher prevalence of STH infection than non-farmers, while housewives had more cases than government employees and casual workers.

The result of this study also supported that of Salwa *et al.*, (2016) that individuals with secondary and tertiary education had a high prevalence of 19.9% among those in education and that unemployed individuals also had a higher prevalence of 21.7 % more than the employed. In contrast, a research in northwest Ethiopia (Abate *et al.*, 2013) found that, while illiterates had a slightly higher frequency of STH, there was no significant relationship between education status and parasite infections.

The increased prevalence might also be attributed to a lack of sanitary facilities at these institutions and at home. There were no adequate toilet facilities in any of the schools visited. As a result, children practice open defecation at school and at home. Only about 36.3% of them go to toilet at home. Those who go to public toilet are about 26.2% while 19.6% go to the bush. The rest of the respondents rotate or combine these three places. The reason for the practice of open field defecation by some of the respondent could be due to poverty and lack of means to construct a latrine or water closet toilets by their parents.

5.1 Limitation of the study

Since the majority of the questions were self-reported, it was impossible to acquire precise data. School children were hesitant to answer some personal questions such as place of toilet facility and providing stool samples. Also since data was collected during the COVID vaccination period some children were unwilling to give out stool samples, affecting the samplesize. As a result, out of the calculated sample size of 384, 347 stool samples were collected with corresponding student questionnaires. Parents who completed the study questionnaire were 318, but only 270 school children had corresponding stool samples and completed questionnaire with corresponding parent's questionnaire.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

In comparison to a research conducted in the Volta Region before the COVID-19 pandemic, the current study found a significantly higher prevalence (41.5 %) of intestinal helminthic infections among children during the COVID-19 pandemic as compared to before COVID-19 outbreak with low prevalence of 12.5% (Orish *et al.*, 2017). *A. lumbricoides, T. trichiura,* and hookworms were the soil-transmitted helminths parasite species found in study area. Hookworm was the most prevalent parasite among the children. The study also identified risk factors associated with STHs infections in the study area; gender, nail cutting behaviour, low usage of anti-helminthic drugs and parent's occupation were all potential risk factor for the prevalence of STH infection.

6.2 Recommendations

- All MDA activities should commence despite suspension, deworming programs should also continue and should target all school-aged children during the COVID- 19 outbreak
- Regular handwashing with soap and water should be encourage by all age groups and in schools.
- Environmental cleanliness and personal hygiene practices in schools should be enhanced to reduce the risk factors for helminth infection.

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APPENDICES

Structured Questionnaire
Introduction

I, Robinson Yaw Vorsah wish to carry out a research on the impact of COVID 19 on the prevalence of **Soil-Transmitted Helminths** among school children in the Volta Region of Ghana. The assessment will seek personal views from the children and parents on knowledge, attitudes and practices concerning transmission of intestinal parasitic infections.

Personal information

#	Questions	Code	Remark
iii	Age group; ,	**01**= 6 - 8, **02**= 9 -11, **03**= 12 - 14, **04**= 15-17	
iv	Sex.	**01**= Male **02** = Female	

Knowledge

1	Have you ever been diagnosed of intestinal parasites	**01 = Yes** **02= No**	
2	Do you take dewormer (anthelminthic drug)?	**01 = Yes** **02= No**	
3	When was the last time you took dewormer (anthelminthic drug)?	**01**= 1-3 months **02**= 4- 6 months **03**= 7- 9 months **04**= 10-12 months **05**= More than 12 months	

Practices

4	Do you wash hands before you eat food at home or in school	**01**= Yes **02**= No **03**= Sometimes	
5	Do you wash hands **with soap before** you eat food at home or in school	**01**= Yes **02**= No **03**= Sometimes	
6	Do you wash your hands after visiting the toilet	**01**= Yes **02**= No **03**= Sometimes	
7	What do you use to wash your hands after visiting the toilet?	**01= Water** **02**= Soap and water	
8	Do you have toilet in your house	**01**= Yes **02**= No	
9	Where do you go to toilet?	**01**= Public toilet **02**= Bush **03**= At home 04= Home and Public toilet 05= Home and Bush 06= Bush and Public toilet	
10	Shoe wearing at home or at school	**01**= Always **02**= Sometimes **03**= Never	

11	Do you cut your nails regularly?	**01**= Yes **02**= No	
12	What do you use to cut your nails?	**01**= I bite my nails **02**= I use blade / knife	

Parents

#	Questions	Code	Remark
ii	Age group; ,	**01**= 30- 35 **02**= 36-40 **03**= 41-45, **04**= 46-50	
iii	Sex.	**01**= Male **02** = Female	
iv	Occupation	**01**= Farmer **02**= Trader **03**= Civil Servant	

Have you given your child any anti helminths drug (dewormer) before COVID? **01**= Yes **02**= No	If **YES**, how often **01**= 3 months **02**= 6 months **03**= 9 months **04**= 12 months If **NO, why** 01= Expensive 02= Scarcity 03= No knowledge about dewormer

Have you given your child any anti helminths drug (dewormer) during COVID? **01**= Yes **02**= No	If **YES**, how often **01**= 3 months **02**= 6 months **03**= 9 months **04**= 12 months If **NO, why** 01= Expensive 02= Scarcity 03= No knowledge about dewormer

INFORMED CONSENT FORM

Consent to participate in study

I, Robinson Yaw Vorsah wish to carry out a research on the impact of COVID-19 outbreak on the prevalence of Soil-Transmitted Helminths among school children in the Volta Region of Ghana. The evaluation will seek personal perspectives from children and parents on knowledge, attitudes, and behaviours regarding the spread of intestinal parasite infections.

Purpose and Description of the Research

This study is aiming at determining the Prevalence and risk factors of Soil Transmitted Helminthiasis and the use of anthelmintic drug among school going children during COVID 19 in Ho West and Afadjato South District, in the Volta Region, Ghana. The finding of this research will be used as the baseline data for future impact assessment of the current interventions against helminths and also will help to choose appropriate control measures to be taken. The results from this study will be published for academic purposes

Participation

Participation is entirely voluntary. It is entirely up to you whether or not to participate in this study, and your reluctance to do so has no bearing on you. Again, you have the option to leave the study at any time. However, your full participation will be much appreciated because it will enable the research's goal to be achieved.

Benefits

Benefit of the research is that the findings will help the government in choosing appropriate control measure by knowing the prevalence and risk factors of these infections.

Data Collection

Participants will be required to submit a fresh tool sample earl in the morning and a questionnaire will be administered to them for identification of risk factors.