RISK FACTORS ASSOCIATED WITH SOIL-TRANSMITTED HELMINTH INFECTIONS AMONG SCHOOL-AGE CHILDREN IN MURINGARI LOCATION, MBEERE NORTH SUB-COUNTY, EMBU COUNTY, KENYA

BY

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A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT OF THE DEGREE OF MASTER OF PUBLIC HEALTH FROM THE SCHOOL OF PUBLIC HEALTH, MOI UNIVERSITY.

DECLARATION

I, the undersigned declare that this thesis is my original work and to the best of my knowledge has not been presented for a degree in any other university. No part of this thesis should therefore be reproduced without the permission of the author and / or Moi University.

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Declaration by Supervisors;

This thesis has been submitted for examination with our approval as Moi University supervisors

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DEDICATION

This thesis is dedicated to my wife, Beth Karani for her support and my children, George Karani, John Karani and Grace Karani.

Abstract

Background: The main species of soil-transmitted helminth (STH) that infect humans are the roundworm (*Ascaris lumbricoides*), the whipworm (*Trichuris trichiura*) and hookworms (*Necator americanus* and *Ancylostoma duodenale*). STH and schistosomiasis (bilharzia) often occur in the same settings. Health records in Kamumu Dispensary situated in Mbeere North Sub-County, Embu County showed that intestinal worm infections in school-age children ranked third among the top ten diseases.
Objective: This study sought to determine the prevalence of STH infections; to assess the impact of helminth infection and to determine risk factors associated with helminth infections among school-age children in five public primary schools.
Methods: A total of 184 school-age children from five public primary schools were included in the study. Stool specimens were collected and examined by the Kato-Katz technique to identify species of worms and estimate their prevalence. A questionnaire and observation checklist were administered to collect data on demographic, socioeconomic, performance of examination, signs and symptoms of disease, absenteeism and water, sanitation and hygiene characteristics. Prevalence of STH infection among SAC was determined by laboratory stool analysis by using Kato-Katz technique. This method was also used to determine any other parasites.
Results: The overall prevalence of schistosome and STH infections was 18.7% (95%CI: 8.3-42.1). *Trichuris trichiura* was the only STH species detected and its overall prevalence was 1.1% (95%CI: 0.3-4.3). *Schistosoma mansoni* was the only species of schistosome infection detected and its prevalence was 18.1% (95%CI: 7.7-42.9.
The main clinical manifestations were abdominal pain, cough and nausea while one of the impacts of soil-transmitted helminths and bilharzia infection was likely to be absenteeism from school which accounted for 578 days lost cumulatively for all the children who indicated missing school due to illness. Children from male headed households were more secure from the infection, aOR = 0.22 (95%CI: 0.08-0.59).
Conclusions: *Schistosoma mansoni* constituted the highest prevalence of infection at 18.1%. High numbers of school days (578) were lost as a result of helminth infection. Children in male headed households were significantly more secure against helminth infections.
Key words: Soil-transmitted helminth infection, bilharzia, water, sanitation and hygiene (WASH), worm infection, school-age children, and Mbeere North Sub-county.

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List of Abbreviations and Acronyms

aOR	Adjusted Odds Ratio
CI	Confidence Interval
CSO	Curriculum Support Officer
DALYs	Daily Adjusted Life Years
EPG	Eggs per gram
IEBC	Independent Electoral and Boundaries Commission
ECIDP	Embu County Integrated Development Plan
IREC	Institutional Review and Ethics Committee
JMP	Joint Monitoring Plan
KPHC	Kenya Population and Housing Census
NACOSTI	National Commission for Science, Technology and Innovation
OR	Odds Ratio
PI	Principal Investigator
PPS	Probability Proportional to Size
SAC	School-age children
SSA	Sub-Saharan Africa
STH	Soil-transmitted helminth
UNICEF	United Nation Children's Fund
URTI	Upper Respiratory Tract Infection
VIP	Ventilated Improved Pit-latrine
WASH	Water, Sanitation and Hygiene
WHA	World Health Assembly
WHO	World Health Organization

Definition of Terms

Soil-transmitted helminth: Intestinal infections in humans caused by worms from the four species of nematodes namely: *Ascaris lumbricoides* (the roundworm), *Trichuris trichiura* (the whipworm) and *Necator americanus* or *Ancylostoma duodenale* (the hookworms).

School–age children: Children aged between 6 and 14 years who may or may not be enrolled in school.

Neglected Tropical Diseases: A group of diseases that historically has been overlooked.

Worm Infection: Parasitic disease of humans in which a part of the body is infected with parasitic worms.

Sanitation: Facilities and services provided for the safe disposal of human excreta and urine.

Hygiene: The set of practices associated with the preservation of health and healthy living.

Impact of infection: The health related signs and symptoms and their effect on education among school-age children.

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CHAPTER ONE

1.0 Introduction

1.1: Background Information

Soil-transmitted helminths (STH) and blood flukes (trematodes) amounting to a considerable public health concern in tropical and sub-tropical areas are *Ascaris lumbricoides*, *Trichuris trichiura*, *Ancylostoma duodenale*, *Necator americanus and schistosomes* (WHO, 2015). One of the reasons as to why they stand out is because of their wide spread prevalence (Hotez, *et al*, 2006). Currently, it is estimated that about one third of almost the 3 billion people that live on less than 2 United States dollars per day in sub-Saharan Africa, Asia and Americas are infected with soil-transmitted helminths (Hotez, *et al*, 2007 & Dold, *et al*, 2011). They are neglected poverty-linked diseases and are more common in developing countries mostly in children who are among the high risk groups (Kassebaum, *et al,2015)*. The soil-transmitted helminths (STH) are intestinal worms in which the immature stages require a period of development or incubation in the soil which is the primary reservoir of eggs before they become infective (Chukwuma, *et al*, 2009). This therefore means that infection cannot occur from fresh faeces and that worms don’t become more numerous in the human as reinfection can only occur as a result of contact with infective stage in the environment *(*WHO, 2019). For eggs to become infective, *Ascaris lumbricoides* eggs must incubate at 5 to 38 ^{0}C for 8 to 37 days, *Trichuris trichiura* at 5 to 38 ^{0}C for 20 to 100 days and hookworm eggs at temperatures below 40 ^{0}C for 2 to 14 days (Brooker, *et al*, 2006). *Ascaris lumbricoides* and *Trichuris trichiura* are both transmitted through faecal-oral route via soil, water, hands and food whilst hookworm species transmission is when infective larvae penetrate the skin (Brooker, *et al*, 2006). Nonetheless, *Ancylostoma duodenale* can be transmitted when larvae are ingested (Bethony, *et al*, 2006). Their life cycles are observed to follow a general pattern. Prolificacy of *A. lumbricoides* is roughly one thirty-four thousand to three hundred and sixty thousand eggs in a day for almost three hundred days and hence discharging many eggs in the environment where human live. Their eggs remain quiescent and withstand severe environmental conditions up to ten years in the soil longer than other soil-transmitted helminths (Kiiti, *et al,* 2020). STH infection is associated with poverty, with the highest prevalence rates discerned where there is poor hygiene; access to safe and clean water is lacking, low sanitation coverage and overpopulation (Hotez, *et al,* 2006 & Olusola, 2012). Persons living in areas with poor water, sanitation and hygiene practices are infected by STH. The population living in such conditions most affected by helminth is the school-age children (SAC). It is not well understood why this age is more affected in comparison with other age groups.

STH infection is a major health problem among school-age children living in rural areas of developing countries and causes morbidity. Children aged between 4 and 15 years harbour the highest intensity of worm (Oyibo, *et al*, 2013). More than 613 million school-age children and about 270 million preschool-age children in the world are estimated to be at risk of STH infection (WHO, 2012). This population of children is among the three billion people estimated globally. The World Health Assembly in (2001) endorsed a resolution urging endemic countries to start seriously tackling STH infections. The strategy for control of STH infections is to control morbidity among the people at-risk living in endemic areas such as the school-age children among others (WHO, WHA54.19, 2001). Some of the strategies used is *Malezi Bora* meaning good upbringing of children which is conducted twice per year during the month of May and November where deworming is done. The age of children targeted by this strategy is twelve to fifty-nine months. However, some health workers administer deworming tablets to school-age children in areas where soil-transmitted helminths are endemic. Health damage due to STH infection is proportional to the number of worms in the host. When infections are of light intensity, the associated morbidity caused is minimal. Nonetheless, infections of moderate to heavy intensity due to large numbers of worms have adverse effect on appetite, growth and fitness physically, nutritional status, impaired cognitive processes, school attendance and cause the loss of an estimated 1.2 million disability-adjusted life-years (DALYs) and are grouped amid the prime causes of absenteeism together with daily adjusted years lost (WHO, 20160) The infections differ in different nations on account of geographical factors, conditions of the environment, income of the family, education, use of unsafe water and hand washing during the critical times. Despite the fact that soil-transmitted helminth infections affect poor population and result to chronic health problems whose clinical manifestation is dangerous, health and global community has ignored them, irrespective of educational and economic prominence (Holmes, 2015).

In low- and middle-income nations with poor hygiene and sanitation, the prevalence of soil-transmitted infections is highest (Utzinger *et al*, 2010). Children at risk of soil-transmitted helminth infections of the age of 1 year to 14 years in India are about twenty-four million, accounting for one quarter of cases worldwide and closely followed by Bangladesh (Grupta *et al*, 2020 & Ohuche *et al*, 2020). The prevalence of STH is estimated to be between 25 and 35 percent among SAC with one or more of the major species of worms. In terms of disease burden in school-age populations in developing countries, intestinal helminth infections rank first among the causes of all communicable and non-communicable diseases.

Study conducted in three Jamaican schools on the effect of helminth intensity on cognitive function in 9-12 years' school-age children, revealed that children with the least academic ability were more likely to harbor larger–than-average worm burden and that the proportion of absenteeism from school, increased with increasing intensity of infection with *T. trichiura*. Study conducted in Nepal showed that the prevalence of STH was highest among children of 6-10 years old and that there was no significant difference in prevalence according to age and sex.

Five hundred and sixty-three million School-Age Children (SAC) inhabit areas where soil-transmitted helminth is spread and this shows that this population is at high risk of being infected due to vulnerability of playing in infected soil (WHO, 2017). It is estimated that 53 million African SAC are infected with *A. lumbricoides*, 50 million with *T. trichiura* and 47 million with hookworm. This infection puts them at highest risk of morbidity (Bethony, *et al*, 2006). Children who are chronically infected with STH have malnutrition, micronutrient deficiencies, poor cognitive function, high rate of school absenteeism (Hotez, *et al*, 2009). STH affect growth and development of children and have a close relationship with the socioeconomic, demographic and ecological factors such as poverty, illiteracy, poor personal and environmental hygiene. The intensity of worms of soil-transmitted helminths infecting a person together with age and immunity, have a relationship with morbidity and mortality (Pasaribu, *et al*, 2019). A family may get worms through children because worms are closely association with health practices and sanitary conditions (Leena, *et al*, 2014). Some of the factors predisposing humans to the infections are use of unsafe water, poor environmental sanitation and hygiene (Ijagbone & Olagunja, 2006; Cairncross, *et al*, 2010;). STH infections are more prevalent among school-age children (5-14 years) in developing countries. The prevalence of *S. mansoni* infection was revealed to be 18.1% in a study conducted in the Great Lake region of East Africa on co-endemicity of *S. mansoni* and STH. However, prevalence for hookworm was 50.0%, while for *A. lumbricoides* *and T. trichiura* each was 6.8% (Clements, *et al*, 2010). Another study on co-endemicity of STH and *S. mansoni* infection conducted among SAC in North Gondar, Northwest Ethiopia showed that 33.7% of the children had *Schistosoma mansoni*. Out of this, 9.5% were coinfected by *S. mansoni* and *A. lumbricoides* and 1.5% with *S. mansoni* and *T. trichiura* (Mathewos, *et al*, 2014).

Kenyan population is approximately 41 million, out of which 14 million are estimated to harbor infection with one or more worm types (Chege, 2021). Out of an estimated population of 9.1 million people at risk of STH, about 2.39 million are children. Early Geo-spatial mapping of these infections showed that they were prevalent in Western and Nyanza region, few parts of South Rift Valley, Coastal region, Central, Eastern and North Eastern regions. (Okoyo, *et al*, 2020) STH infections among school children has remained high irrespective of periodic deworming (Ngonjo, *et al*, 2016). A study conducted in Mwea Irrigation Scheme, Kenya on STH and schistosoma species revealed that prevalence of *S. mansoni* was 17.3%, hookworm 5%, *A. lumbricoides* 4.6% and *T. trichiura* 3% (Njiru, *et al*, 2016). Another study conducted in the same area showed prevalence of *T. trichiura*, *A. lumbricoides* and *S. mansoni* as <1%, 3% and 5.5%, respectively (Sakari, *et al*, 2017). The data obtained from the health facilities in Mbeere North from the records office showed that children from Kamumu and Kathanje dispensaries had high intestinal worm infection. It is on this bases that the investigator used simple random sampling to pick Kamumu dispensary to conduct the study.

This study aimed at identifying risk factors associated with STH infection among school-age children in the public primary schools in Muringari location, Mbeere North Sub-County, Embu County.

1.2: Research Problem Statement

Soil-transmitted helminth infections are among the most common infections worldwide and affect the poorest and most deprived communities. Over 600 million school-age children live in areas where these parasites are intensively transmitted (Shrestha & Maharjan, 2013).

A study on risk factors associated with soil-transmitted helminth infection has never been carried out in Muringari location. The health records from Mbeere North Sub-County Health Records Office indicated that intestinal worm infection ranked fifth among the top ten diseases / conditions as shown on table one.

Table 1: Top ten diseases in Mbeere North Sub-County in 2016

MBEERE N0RTH: TOP TEN DISEASES/CONDITIONS IN 2016	
Upper Respiratory Tract Infection	63159
Diseases of the skin	14729
Confirmed Malaria cases	7061
Diarrhoea	6493
Intestinal worms	**4468**
Arthritis	4268
Eye Infections	3907
Pneumonia	3312
Ear Infection	2609
Hypertension	1797

Source: Mbeere North Sub-County Health Records Office

The health facility data on the top ten diseases / conditions in Mbeere North, showed that intestinal worms is ranked third in Kamumu dispensary affecting school-age children more than any other cohort as shown on table two.

Table 2: Top ten diseases at Kamumu dispensary in 2016

KAMUMU DISPENSARY: TOP TEN DISEASES/CONDITIONS	
Upper Respiratory Tract Infection	4056
Disease of the skin	1320
Intestinal Worms	**1284**
Diarrhoea	348
Arthritis	300
Eye Infection	264
Other Injuries	192
Chicken pox	156
Ear Infection	122
Urinary Tract Infection	120

Source: Kamumu Dispensary Health Records

1.3 Justification

More than 613 million school-age children in the world are at risk of STH infection (WHO, 2010). STH infection among children in Kenya remains high despite periodic administration of deworming medicines (Ngonjo, *et al*, 2016). These infections contribute to the perpetuation of poverty by impairing the cognitive performance, growth of children as well as reducing the work capacity and productivity of adults (WHO, 2005).

The findings will therefore provide useful information for designing feasible control strategy within the study area and Mbeere North at large. Identification of risk factors associated with STH infection among SAC will culminate in recommendations for focused interventions leading to improved health, increased school attendance, increased ability to learn and improved academic performance.

Helminth infection control is currently being directed toward SAC who are known to carry the heaviest infections and are the most likely to suffer from associated morbidity.

The data obtained from Kamumu dispensary on the top ten diseases and or conditions showed that intestinal worm infection ranked third. However, the diagnoses were done clinically by the nurse in-charge based on signs and symptoms reported by the patients and / or guardians without subjecting them to laboratory stool testing since this service was not available by the time of collecting data for this study.

1.3 Research Questions

1. What is the prevalence and intensity of STH among school-age children in Mbeere North Sub-County, Embu County?
2. What is the impact of soil-transmitted helminth infections among school-age children in Mbeere North Sub-County, Embu County?

1.4 Objectives

1.4.0 Broad Objective

To determine the dynamics of infection and identify modifiable risk factors that could be used as targets for the control of soil-transmitted helminth among school-age children in Muringari location, Mbeere North Sub-County.

1.4.1 Specific Objectives.

1. To determine the prevalence of soil-transmitted helminth infections among school-age children in Muringari Location, Mbeere North Sub-County, Embu County.
2. To assess the impact of helminth infections among school-age children in Muringari Location Mbeere North Sub-County, Embu County
3. To determine risk factors associated with helminth infections among school-age children in Muringari Location Mbeere North Sub-County, Embu County

CHAPTER TWO

2.0 Literature Review

2.1 Prevalence of Soil-Transmitted Helminth Among School-Age Children

Estimating different soil-transmitted helminth infections, requires well founded estimates of prevalence for targeted control measures. For example, a study conducted to determine prevalence of helminths sheltered by the school-age children in Delhi India, showed that 54.4% percent had *Ascaris lumbricoides* while 4.8% had *Trichuri trichiura* with no hookworm infection. Infections against all *Trichuris* and nearly all *Ascaris* was of light intensity with few infected with *Ascaris* with moderate intensity. However, one child had infection which was of heavy intensity (Kattula, *et al*, 2014). Another study conducted to assess the prevalence of soil-transmitted helminth infections and associated factors among school children in Durbete, Northwestern Ethiopia revealed that about 54.9% individuals were found to be infected with at least one intestinal helminth species (Alelign, *et al*, 2015). Another study conducted to determine the prevalence and associated factors of soil-transmitted helminth infections in Babile in Ethiopia revealed that prevalence of *S. Masoni* was 4.3% with boys being more infected than girls and the infection increased linearly with age (Tadesse, *et al*, 2005). A school-based national survey conducted in Ethiopia showed a prevalence of 29% STH infection among SAC, comprising of *A. lumbricoides* 21%, hookworm 9.2% and *Trichuris truchiura* 4.1%, respectively (Martins, *et al*, & Cora, 2012). A study carried out in Tachgayint Woreda, North-central Ethiopia on prevalence, intensity of infection and associated risk factors of soil-transmitted helminth infections among school children revealed that overall prevalence of STH was 36% while overall mean of egg per gram was found to be 464.53 EPG of stool. The count for *Trichuris trichiura* was 238.0 eggs per gram and thus light infection (Eyayu, *et al,* 2022). Another study conducted to investigate the effects of STH and *S. mansoni* parasite infections on nutritional status of school children in Mwea Irrigation scheme, Kenya revealed that prevalence of S. *mansoni* was 17.3%, hookworm 5%, *A. lumbricoides* 4.6% and *T. trichiura* 3% (Njiru, *et al,* 2016). Also a study conducted to assess the public health significance of STH, *schistosomiasis*, and other intestinal parasitic infections, through fecal examination in Mwea irrigation scheme, in Kirinyaga, Kenya showed prevalence of *T. trichiura, A. lumbricoides* and *S. mansoni* as <1%, 3% and 5.5%, respectively (Sakari, *et al,* 2017). Also, another study conducted in Mwea, Kirinyaga on prevalence of intestinal parasitic infections and associated water, sanitation and hygiene risk factors among school-age children established a prevalence of 70.5% which was far much higher than the one found in this study (Njambi, *et al,* 2020). A study conducted in Lurambi, Kenya on risk factors associated with helminth intestinal infection showed that the overall prevalence of soil-transmitted helminth and *schistosomiasis* was 14.4%.

2.2: Species of Soil-Transmitted helminth infecting the School-Age Children

Over one billion people are infected with one or more species of soil-transmitted helminth (Utzinger, *et al*, 2004). For example, *Ascaris lumbricoides* infected more pupils (50.7%) compared to hookworm species and *T. trichiura* being 32.6% and 23.2%, respectively according to a study conducted on the prevalence of soil-transmitted helminth infections in Ife East Local Government Area of Ile Ife, Osun State, Nigeria (Salawu, *et al,* 2015). Another study conducted in Northern Ethiopia found that the species infecting school children were hookworms, (46.9%) *A. lumbricoides*, (13.9%) and *T. trichiura* (2.3%), respectively (Alelign, *et al,* 2015). Another study conducted in Kakamega, Kenya among school children found that species of A. lumbricoides was more common (Ngonjo, *et al*, 2016). Also, species found infecting school children in a study conducted in Mwea, Kenya were *A. lumbricoides* (43.5%) and hookworms, (1.8%), respectively (Ngonjo *et al*, 2016).

2.3 Age of School Children with Level of STH Infection

The Geo-spatial distribution of soil-transmitted helminth is influenced by age among other factors. For example, age has been shown to contribute to the transmission of STH infection in a study carried out on assessment to determine STH infection among school-age children (5-14 years) in developing countries at Lake Awassa area, South Ethiopia. Another study conducted to estimate the prevalence of STH infections among school-age children in Kaski District of Western Nepal showed that the prevalence of STH was highest among children of 6-10 years old. Also, a study conducted in Nigeria showed that the prevalence increased from 31.1% among children aged 4-5 years to 50.5% in age group 8-9 years and declined to 31.3% among 13-14 years old children (Salawu, *et al*, 2015). A study conducted in Northern Ethiopia showed that the odds of STH infection were greater among school children of 10-14 years old than those of lower age cohorts (Alelign, *et al*, 2015).

2.4 Association of Water, Environmental Sanitation and Hygiene with STH Infections

Geo-spatial distribution of soil-transmitted helminth is influenced by factors such as poor environmental sanitation, lack of personal hygiene, use of untreated water, age and socio-economic status (Nasr, *et al*, 2013). Soil-transmitted helminth life cycles involve environmental contamination with human faeces containing infective eggs, with major risk factors being poor access to clean and safe water, sanitation and hygiene. There is evidence that soil-transmitted helminth infection is associated with non-availability to latrine, not wearing shoes and lack of hand washing (Ziegelbauer, *et al*, 2012 & Strunz, *et al,* 2014). Access to water, sanitation and hygiene is necessary for sustained efforts in prevention and control of STH infections (Campbell, *et al,* 2014). Availability of reliable data on school water sanitation and hygiene nationally is inadequate (Unicef, & UNICEF 2016). STH infections are prevalent in developing countries where poor sanitation and lack of adequate clean and safe water are common (WHO, 2002). The risk of STH infection is increased by lack of personal and environmental hygiene, sanitation, education, walking barefoot and poor nutritional status (WHO, 2002; Ostan, *et al*, 2007; Vandemark, *et al*, 2010; Alemu, *et al*, 2011). A study conducted to determine prevalence and risk factors of Soil-Transmitted Helminth infections in Delhi, India showed that school children attending classes without shoes (odds ratio, OR=3.06; 95% confidence interval=1.47-6.371) and hand dirty nails that were not trimmed (odds ratio, OR=3.32; 95% confidence interval 1.82-6.05) were risk factors that had significant association (Kattula, *et al*, 2014).

School-age children have frequent playing habits and low level of awareness resulting to high prevalence of STH infection (Degarege, *et al*, 2009; Degarege, *et al*, 2013 & Degarege *et al*, 2014). Use of safe water can reduce the prevalence of STH infections among communities. For example, reduced odds of any STH infection was reported in a systematic review among people who used treated water, and washed hands after defaecation with water and soap (Ziegelbauer *et al*, 2012; Strunz *et al*, 2014). A study conducted in Delhi India among school-age children on hand washing without soap after visiting toilet in school (odds ratio, OR=4.06; 95% confidence interval =2.37-6.06%) and contorted hand washing before meals (odds ratio, OR=4.80; 95% confidence interval = 2.78-8.30) were significant factors for the helminths infection. The study showed that school children who did not wash hands after visiting toilet were

2.34 times at risk of helminths infection which was given as adjusted odds ratio while those with contorted hand washing before taking meals had 2.29 times risk of helminths infection (Kattula, *et al,* 2014). Usually, worm infection occurs in children when they walk barefoot, drink contaminated water both in school or home or when they come in contact with contaminated soil. In developed countries, environmental sanitation and high standard of living have resulted in a reduction in the prevalence of intestinal parasites (WHO, 2015).

Poor environmental sanitation and hygiene have been shown to contribute to the transmission of STH infections. For example, a study conducted in Sanliurfa, Turkey showed that where soil is polluted with faecal matter, transmission of STH infection is high. Another study conducted in Jhajjar district, India showed that 76.5% of SAC had untrimmed dirty nails (Ramesh *et al*, 2015). Also, an annual national helminth survey conducted in Lao People's Democratic Republic (Lao PDR) showed that the prevalence of STH infection was high due to poor sanitation among other factors (Samphou, *et al*, 2012).

In India, worm infection is one of the leading causes of morbidity among children. Approximately 7% stool of Indian population has eggs of hookworms and over two million children below the age of four years have been infected with hookworm (WHO, 2015). Disability adjusted life-years (DALYs) lost due to all causes of worm infection is 12.3% in girls and 11.4% in boys, respectively.

Latrines usage can reduce the prevalence of STH infections among communities. For example, a study in Nigeria showed that pupils who use latrines for faecal disposal were 0.5 times less likely to be infected with *A. lumbricoides* than pupils using bush for open defaecation (OD). Hand hygiene and foot wear can also reduce the prevalence of STH infections among communities. For example, the odds of being infected with *A.*

lumbricoides among pupils who washed hands after visiting toilet was 0.6 less likely and 2.2 more likely to those who did not wash hands after visiting toilet (Salawu, *et al*, 2015). Also, a study conducted in Northern Ethiopia showed that school children who did not wash hands before eating (aOR = 3.80, 95% CI = 1.02, 14.23) and did not wear shoes (adjusted Odds Ratio - aOR = 2.24, 95% CI = 1.05, 5.57) had higher probability of infection with STH than those who wore shoes and washed hands before eating, respectively (Alelign, *et al*, 2015).

Also a study conducted on the behaviour of hand washing with soap in schools in Kenya, showed that only 1% did so and this has bearing on STH infection. Soil is the primary environmental reservoir for STH eggs prior to transmission. Contaminated environment can increase the risk of STH infections among the communities. For example, soil samples collected during a study from the house entrance and latrine entrance of households in Kakamega County showed that the prevalence of STH eggs in soil was 19.4% and 11.3% from the house and latrine entrance, respectively (Steinbaum, *et al*, 2016). In areas that lack adequate sanitation, eggs are passed in the faeces of infected people and contaminate the soil. Eggs are attached to vegetables and get ingested when they are not well cooked, washed or peeled. They are also ingested from contaminated water sources and when children play in the contaminated soil and then put their hands in their mouths without washing them (Yahia, *et al*, 2023).

2.5 Association of STH with Socioeconomic Factors

Low socioeconomic levels are known to contribute to the transmission of soil-transmitted helminth infections. For example, about one third of the three billion people that live on less than two US dollars per day in developing regions of Sub-Saharan Africa, Asia, and the Americas are infected with one or more helminths (Hotez, *et al*, 2007). Soil-transmitted helminths are influenced by poor socio-economic conditions including housing, low education level, and low family income. STH is an infection which is associated with poverty, delaying social and economic development in areas where it is prevalent (Steinmann, *et al*, 2006; Vos, *et al*, 2010 and Colley, *et al*, 2014). These infections contribute to extend poverty by reducing the workability and productivity of adults (King, 2010).

The odds of STH infection were similar between school children who had literate and illiterate parents. This is according to a study conducted in Northern Ethiopia (Alelign, *et al,* 2015). A study conducted in Timor-Leste showed a protective gradient for increasing level of education particularly for parents with the highest education level as compared to those who never attended school. (Campbell, *et al*, 2016). A study conducted in Nigeria showed that pupils whose parents were farmers and had low level of education were 3.0 times more likely to be infected with *A. lumbricoides* than pupils whose parents were civil servants (Salawu, *et al*, 2015).

2.6 Impact Associated with Helminth Infections

Soil-transmitted helminths such as *A. lumbricoides*, hookworm and *T. trichiura* can cause malnutrition, damage intestinal mucosa and chronic reduction of food intake respectively (Hall, *et al,* 2008). In Ethiopia, helminth infections are the second most predominant causes of outpatient morbidity. This is because of unsafe drinking water supply and low latrine coverage. A study conducted in Northwestern, Ethiopia revealed that a child infected with soil-transmitted helminths particularly hookworm and also *S. mansoni* is associated with increased risk of anaemia (Yimam, *et al,* 2016) A study conducted to determine the prevalence and associated factors of soil-transmitted helminths in Babile I Ethiopia revealed that 41.7% of sampled school children complained of signs and or symptoms related with parasitic intestinal infections.

Majority of the children complained of abdominal pain, vomiting, diarrhoea and nausea. STH infections among school-age children has been shown to be associated with negative impact of their health. For example, a study carried out in Busia, Kenya revealed that infection with STH resulted in growth stunting, diminished physical fitness and impaired memory and cognition. These health consequences impair childhood educational performance, reduce school attendance, lead to poor academic performance, high dropout rates and reduce future wage earning capacity (Baird, *et al*, 2011; WHO, 2012). It also causes recurrent gastrointestinal and upper respiratory tract infection (URTI) contributing to high morbidity and mortality in children (Yared, *et al*, 2001). They cause morbidity by affecting nutritional status, affecting cognitive processes, causing complications that need surgical intervention such as intestinal obstruction and increasing susceptibility to other infections. Children infected with STH have been found to be absent from school. For example, a study conducted in Jamaica on absenteeism among pupils, revealed that those infected with moderate to heavy loads of *Trichuris trichiura* were absent from school more often than their uninfected counterparts. They therefore lost more days due to the infection. These parasites destroy tissues and organs of the host, cause abdominal pain, diarrhoea, and intestinal obstructions among other clinical manifestation (Bethony, *et al*, 2006). Infections from soil-transmitted helminth scarcely cause mortality safe for chronic and stealthy result as well as effect on nutritional status of the human host. Soil-transmitted helminths affect function of the gastrointestinal tract negatively and most stages of digestion and absorption are likely to be influenced. This further affects some of the most nutrients essential in the body such as sodium, potassium and chloride which are related to vomiting and diarrhoea. Lighter infections may lay a threat to the health of the children if the nutritional status of the community is appalling (King, et al, 2010).

Nonetheless, it is not easy to detect soil-transmitted helminths and *schistosomiasis* because of the absence of clinical symptoms.

2.7: Conceptual Framework

This framework is a research tool intended to assist a researcher to develop awareness and understanding of the situation under scrutiny and to communicate it in a concise and clear manner on the outcome of infection.

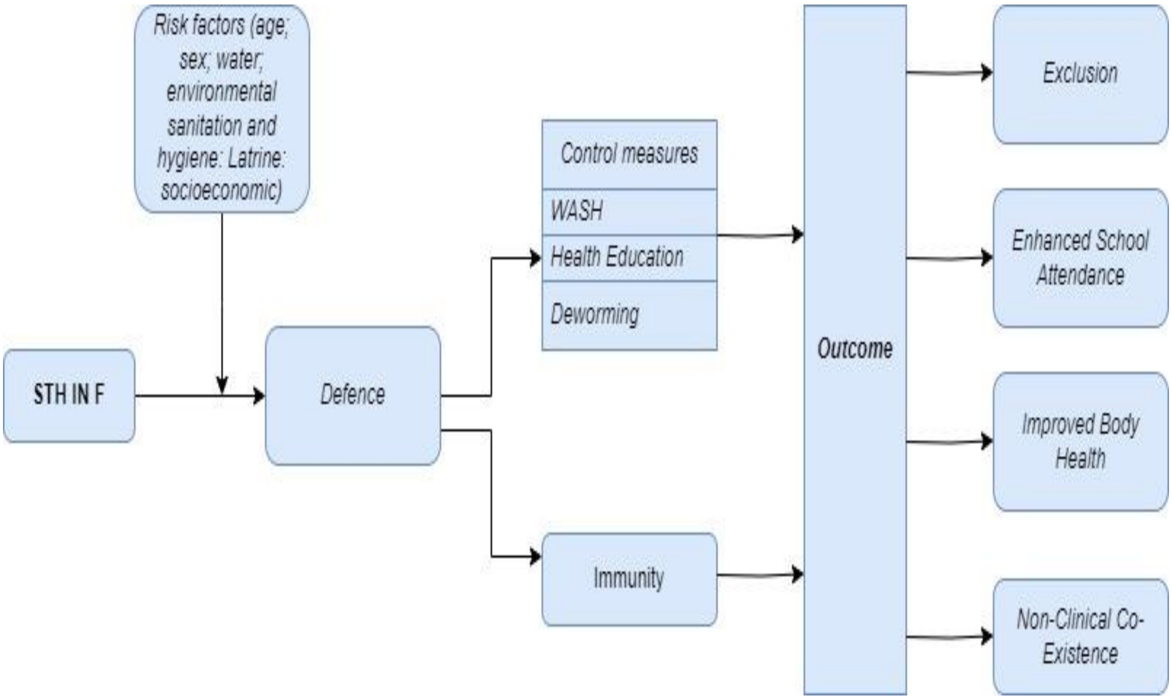
The most common clinical manifestations for children infected by STH and Schistosomes are fever, chills, weakness, headache, anorexia, nausea, vomiting abdominal pain and general malaise. Severe watery diarrhea, sometimes bloody stools, nonproductive cough, and rapid weight loss may develop (El-Garen, 1998).

When the infective stage of soil-transmitted helminths is in the environment, their effect on the host will be determined by the level of immunity, absence or presence of control measures and the risk factors. The immune response of a host is determined by its relationship with the STH. It balances an effective response to the parasite with limiting potentially detrimental immunopathology and exhausting vital resources (Graham, *et al,* 2005). Likewise, the parasite has to promote an immune response in the host but that also protects the host from excessive pathology and infection by other potential pathogens. Therefore, it is highly likely that anti-parasite immune responses have evolved to limit parasite burden and promote rather than to cause rapid and total parasite expulsion.

The interaction between immunity and risk factors is bi-directional. This means that when risk factors are at optimal, then immunity is enhanced and likewise when it is at sub-optimal, immunity is low and therefore susceptible to infection. The immunity will predispose STH and schistosomes infections if the host is exposed to the risk factors.

Therefore, resistance to infection can be done when the child avoids risk factors in the environment. The outcome were exclusion, enhanced school attendance, improved body health and non-clinical co-existence and intervening variables were immunity and control measures while risk factors were the independent variables.

Figure 1: Conceptual Framework



Source: Author, 2021

CHAPTER THREE

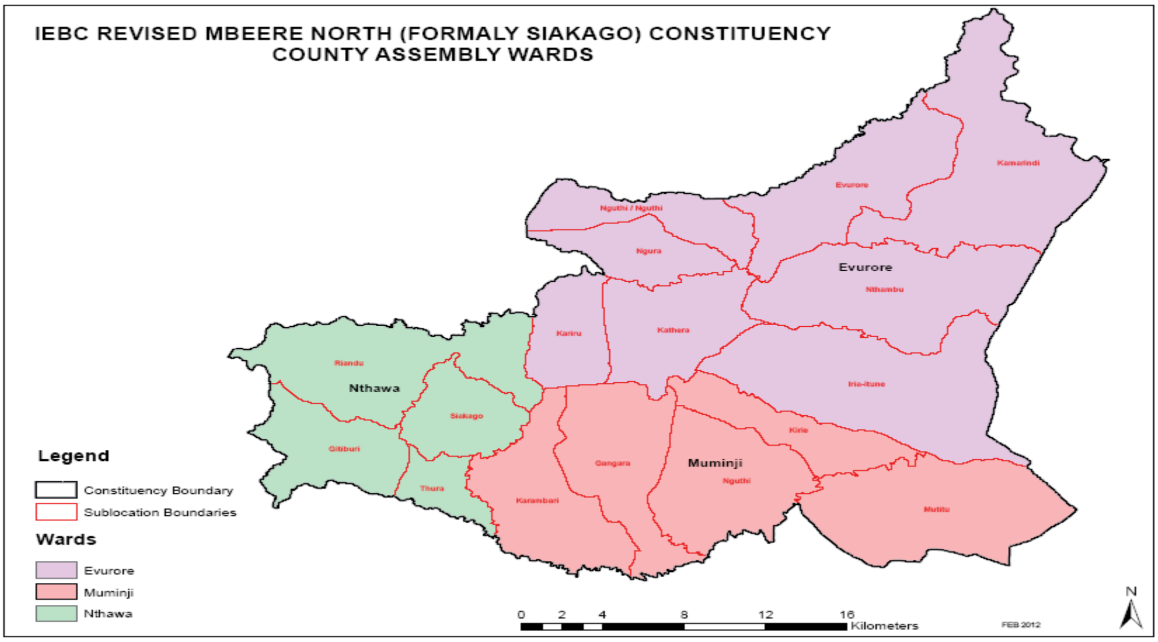
3.0 Methodology

3.1: Study Site

The study was carried out in Muringari location, Kamumu education zone in Mbeere North Sub-County, Embu County in 2017. Muringari lies approximately latitude 0^{0} $34^{/}$ $59.99^{//}$N and longitude 37^{0} $37^{/}$ $59.99^{//}$E. At the time of the study, the location had a projected population size of 4,222 with 1,009 households and five public primary schools. It has a warm climate with bi-modal rainfall pattern of long rains and short rains occurring between March & June and between October & December, respectively. Annual rainfall averages range between 640mm and 1,100mm while temperature ranges from 15^{0}C to 30^{0}C (KPHC, 2009 & ECIDP, 2013-2017)

The area is a rural setting where land use is predominantly agricultural (livestock keeping and crop production). The study was conducted in Karuari, Kathigagaceru, Gatororori, Itururi and Rwanjeru Primary Schools, Muringari Location, Kamumu education zone, Evurore Ward, with the aim of assessing risk factors for STH infections among SAC. Some of these schools are located near the Ena river which may predispose school children to water-based diseases during washing, swimming and even crossing when going to and from school. Figure two shows map of the study area.

Figure 2: Map of the study area



Source: IEBC Revised Mbeere North Constituency

3.2 Study Population

The study group or study unit was school-age children (6-14 years). These were children in class one to class eight as various studies conducted show that they are most affected by STH. They were drawn from five public primary schools within Kamumu education zone. There were twenty-seven primary schools in Kamumu education zone with an enrolment of 5,029 pupils.

3.3: Study Design

This was a cross-sectional school-based study which utilized representative, cluster and stratified sample and involved administration of a questionnaire and checklist to collect demographic, WASH and socioeconomic data. Additionally, laboratory stool analysis by use of Kato-Katz technique was done to determine prevalence of STH infection among SAC. The study was conducted between July 2017 and June 2018. The quantitative research method was used for data collection.

3.4 Sample Size Determination

The sampling frame was all the twenty-seven (27) primary schools within Kamumu education zone. The data was obtained by the assistance of the Sub-County Director of Education, Mbeere North; Curriculum Support Officer (CSO) of Kamumu zone and the area chief. A list of the twenty-seven schools was obtained in the zone then applied simple random sampling technique to select five schools from the list. Children from class one to eight from selected primary schools were sampled. Simple random sampling method was used to select children.

The sample size was estimated using the Israel's formula (Israel, 1992). The reference prevalence of 13% was considered from a study on STH through school health programme conducted in Mbeere district though unpublished (Mwanje *et al*, 2009) at 95% confidence interval (CI) and margin of error of 5% was used.

The unit of sampling and analysis were the location, schools and the children.

$$n = \frac{Z^2 x\ (p)(q)}{ME^2}$$

Where n= desired sample size of the total population

Z= standard normal deviation (1.96) usually set at 95% confidence level.

P= proportion in the population estimated to have a particular characteristic e.g. prevalence of STH which is 13% (0.13).

q= (1-p) = 1-0.13=0.87

ME= Margin of error (0.05)

Calculation of sample size when N is > 12,000

$$n = \frac{1.96^2 x\ 0.13\ x\ 0.87}{0.05^2}$$

=173 (desired sample)

Adjustment is needed since (N), the population size is < 12,000 using the following formula

$$n = \frac{Nn}{(N+n-1)}$$

$$= \frac{5.029\ x\ 173}{5.029 + 172}$$

= 167.127

= 167 (estimated sample size)

10% of the sample size was added to the estimated sample to take care of non-compliance or non-response. rate.

The sample size therefore was184 school-age children and were therefore included in this study. In this study, simple random sampling was used to select participants per school hence, there was no need to adjust the sample size using the design effect.

3.5 Sampling Procedure

A two-stage sampling procedure was used to select schools and pupils. The zonal education officer referred to as the curriculum support officer gave list of all the public primary schools from that zone which formed the sampling frame forming stage one. The population of all the schools within the education zone was divided into two clusters. Cluster sampling was used to randomly select the five schools from those located near and far from Ena river. The schools were visited one week prior to the survey date so as to explain the purpose of the survey to the head teacher together with the school community. Stage two entailed the head teachers availing a list of all pupils from the selected schools within the age bracket between 6 and 14 years. The school children were stratified on class levels (class one to class eight).

Simple random sampling method was used to select five schools from the twenty-seven primary schools in Muringari location. The basis of sampling was per the World Health Organization (WHO) guidelines which recommend that a sample of five schools on the minimum and ten school on the maximum depending on resources is picked through simple random sampling technique from the sampling frame when establishing prevalence and intensity of helminths and schistosomes among the school-age children (Njambi *et al*, 2020). The guidelines proposed that five to ten schools be selected. Children were requested to inform their parents avail themselves in the agreed date. The head teachers, parents and children were explained the purpose of the study and procedure for the stool sample collection by the principal investigator in a confidential style. Issues of embracing informed consent, risks and benefits of the study, volunteerism, confidentiality and procedures to be used were explained at length to selected pupils and parents and /or guardians. A list of children from each class and their age was obtained from the class registers. Systematic random sampling technique was used to select children and a sample drawn using class registers as the sampling frame. Classes were stratified in the primary schools. A total of 184 children from the five primary schools were selected randomly. Probability proportional to size (PPS) sampling method was utilized to allocate samples per school then select number of children from each stratum who were allocated by dividing the number of student in the stratum by the total number of pupils in the school. The proportion was further multiplied by the total sample size. This method took care of any variability among clusters. This is a sampling procedure under which the probability of a unit being selected is proportional to the size of the ultimate unit, giving larger clusters a greater probability of selection and smaller clusters a lower probability. It is most useful when the sampling units vary considerably in size because it assures that those in larger sites have the same probability of getting into the sample as those in smaller sites. When samples from different sized subgroups are used and sampling is taken with the same probability, the chances of selecting a member from a large group are less than selecting a member from a smaller group.

This was arrived at by taking the total number of children from class one to class eight in each sampled school forming the numerator whilst the total number of children in the five public primary schools as the denominator. The answer arrived at from each public primary school was multiplied by the estimated sample size of 184. Simple random sampling technique using class registers as the sampling frame was used. Papers written “yes” equivalent to the estimated sample size per class were folded and put in a bowl together with those written “no”. They were mixed thoroughly well and children asked to pick one each. Stool samples were drawn from those picking yes and further subjected to the interviewers’ schedule.

Population of school-age children selected per sampled school

Out of 184 children selected from the five primary schools randomly, only 182 were able to give stool sample. Probability proportional to size (PPS) sampling method was utilized. This method took care of any variability among clusters. Simple random sampling was used to identify number of children to participate in the study per class. During sampling, classes were weighted for population and not for age groups. However, age set was aggregated thereafter after obtaining the results. Table three shows the details.

Table 3: Population of school-age children selected per sampled school

Name of Primary School	**Population of Children Per Class**								**Total Number of children in school**	**Per capita Sample Size for the School**
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8		
Karuari	26	26	26	38	44	59	41	22	282	**44**
Kathiga gaceru	30	24	27	32	39	41	36	20	249	**40**
Gatorori	30	28	26	40	29	32	29	18	232	**37**
Itururi	30	28	28	29	31	27	30	14	217	**35**
Rwanjeru	15	19	23	30	24	23	25	19	178	**28**
Total	**131**	**125**	**130**	**169**	**167**	**182**	**161**	**93**	**1158**	**184**

Distribution of Sample Size per Class and Gender

Each class was weighted so as to distribute sample size per class and gender equally. This was done by dividing sample size calculated and arrived at per class then divided by 8 classes as shown in table four. Equal number of males and females were taken per class for each school hence equal weighting per gender and class. The table four below shows the distribution.

Table 4: Distribution of Sample Size per Class and Gender

Name of Primary School	**Distribution of Sample Size Per Class and Gender**								**Number of children sampled per school**	**Distribution of Sample Size per class and gender**
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8		
	M F	M F	M F	M F	M F	M F	M F	M F		
Karuari	3 3	3 2	3 3	3 2	2 3	3 3	2 3	3 3	**44**	6
Kathigaceru	2 3	3 2	2 3	3 2	2 3	3 2	2 3	3 2	**40**	**5**
Gatorori	2 3	2 2	2 2	3 2	3 2	2 3	2 2	3 2	**37**	5
Itururi	2 3	2 2	2 2	2 2	3 2	2 2	2 2	3 2	**35**	**4**
Rwanjeru	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	**28**	4

3.6 Inclusion Criteria

Children in classes 1-8 without health complaints such as diarrhea of any nature.

Household heads of the selected children.

3.7 Exclusion Criteria

Children with history of taking deworming medicines in the past one month. Also, those in pre-school were excluded in the study.

3.8 Laboratory Testing

Guidance was given to all the pupils on the way of availing two grams of fresh stool sample. Each selected pupil was given a clean, dry and leak proof disposable labeled container (poly pot) with unique identification number (ID) to code the name linked to the parasitological questionnaire bearing class, sex, age and school; wooden spatula; newspaper and tissue paper. Pupils were required to drop fresh stool on the newspaper then collect using the spatula and put in the poly pot until full. This was to ensure hygienic transfer of the stool. Class one and two children were assisted by their teachers in provision of stool samples. The samples were transported to Kamumu dispensary laboratory in cooler boxes which was maintaining a temperature of less than 10^0C for microscopic screening within the same day where the Kato-Katz technique was used for processing of and preparation of double slides before examination and counting of STH eggs by light microscopy. The principal investigator, the research assistants and laboratory technologists checked for identification number on the labels, quantity of feaces and hygiene for dirt. It is during this period that it was discovered that two poly pots did not have stool sample reducing sample size from one hundred and eighty-four to one hundred and eighty-two. This was followed by interviewing each pupil on water, sanitation and hygiene using an instrument that was pre-tested. This technique is for both qualitative and semi-quantitative diagnosis of soil-transmitted helminths and schistosomiasis. The laboratory technologists checked for the quality of reagents and instruments. To remove large particles, faecal matter was pressed through a mesh screen. After which the sieved sample was passed through the hole of a template capable of holding 41.7 mg as guided by WHO kit on a slide. The template was removed cautiously and the remaining sample on the slide was covered with a certain size of cellophane soaked in glycerine malachite green and placed on the smear and the slide was then turned upside down, pressed and allowed to spread evenly. Malachite green is a positive stain which gives colour to make it easy to observe parasite. The Kato-Katz slides were examined, read and eggs identified then counted for those that were positive within one hour for its preparation under the compound microscope at a magnification of x10 objective for hookworm eggs (Mwandawiro *et al,* 2013). Examination, identification and counting of *Ascaris lumbricoides* and *Trichuris trichiura* eggs were examined sixty minutes later. Counting of egg was done per slide then multiplied by a factor of 24 to help get eggs per gram of faeces. Calculation was done leading to the total number of eggs which were expressed as eggs per gram of faeces (EPG) to determine whether infection was low, medium or heavy in school-age children according to WHO guidelines of classification. Infections resulting from soil-transmitted helminths is defined as light, moderate and heavy intensity to express severity (Erazo, D., & Cordovez, J. (2016). The data was entered into a parasitological data collection form. Ten percent of the everyday examined slides were subjected to systematic random examination by the qualified and trained team leader for quality control following standard operating procedures for Kato-Katz technique. A qualified microscopic did double reading of the slides. The purpose of doing this was to avoid any discrepancy on the stool examination results between the first and the quality control test. All the laboratory analysis of the stool samples was done by the two Laboratory Technologists holding the qualification of diploma and higher diploma in laboratory science and parasitology respectively. They worked in Kimbimbi Sub-County Hospital Laboratory which is the Eastern regional entomology laboratory.

Laboratory testing was done to estimate the prevalence of helminth and intensity of worms.

Prevalence of infection was determined by obtaining percentage of school-age children who had any of the soil-transmitted helminth and *schistosomiasis* infection. Intensity of infection was determined by the number of soil-transmitted helminth and / or schistosomiasis infecting the school-age children. This was measured through indirect method since it's less intrusive, more commonly done and it is convenient, by counting eggs found in the stool sample which is expressed as eggs per gram (epg). The following below table five shows species of soil-transmitted helminths, their sizes, shapes and features for ease of identification.

Table 5: Criteria for Identification of helminth eggs

Species	Size	Shape	Specific Features and Variations
Trichuris trichiura	54 µm x 22 µm. Range, 49-65 µm x 20-29 µm.	Elongated, barrel-shaped with a polar "plug" at each end.	Polar plugs are distinctive. Eggs occasionally are oriented in a vertical or slanted position and may not be readily recognized. A gentle tap on the coverslip will usually reorient the egg. On rare occasions, atypical eggs lacking polar plugs may be seen.
Ancylostoma duodenale ***(Hookworm)***	60 µm x 40 µm. Range, 57-76 µm x 35-47 µm.	Oval or ellipsoidal with a thin shell.	Occasionally, eggs in advanced cleavage (16 or more cells) or even embryonated may be seen. Rhabditiform larvae may be present if the specimens are old. Species identification cannot be made on eggs alone; therefore, eggs should be reported simply as hookworm.
Necator americanus ***(Hookworm)***	65 µm x 40 µm. Range, 57-76 µm x 35-47 µm.	Oval or ellipsoidal with a thin shell.	Occasionally, eggs in advanced cleavage (16 or more cells) or even embryonated may be seen. Rhabditiform larvae may be present if the specimens are old. Species identification cannot be made on eggs alone; therefore, eggs should be reported simply as hookworm.

Schistosoma mansoni	140 µm x 66 µm. Range, 114-180 µm x 45-73 µm.	Elongated with prominent lateral spine near posterior end. Anterior end tapered and slightly curved.	Lateral spine. Found in feces; in rare cases, in urine also. Eggs are discharged at irregular intervals and may not be found in every stool specimen. Are rare in chronic stages of infection.
Taenia saginata Taenia solium	35 µm. Range, 31-43 µm.	Spherical with thick striated shell.	Thick, striated shell. Eggs of *T. solium* and *T. saginata* are indistinguishable and species identification should be made from proglottids or scolex. "*Taenia*" spp. Should be reported if only eggs are found.
Hymenolepis nana	47 µm x 37 µm. Range, 40-60 µm x 30-50 µm.	Oval. Shell consists of 2 distinct membranes. On inner membrane are two small "knobs" or poles from which 4 to 8 filaments arise and spread out between the two membranes.	Polar filaments.
***Ascaris lumbricoides* fertile egg**	60 µm x 45 µm. Range, 45-70 µm x 35-45 µm.	Round or ovoidal. With thick shell.	Mamillated albuminous coat or covering on outer shell. Coat is sometimes lost and decorticated eggs have a colorless shell with gray or black internal material. Eggs may be in 2, 4, or more cells, or contain a fully developed larva.
***Ascaris lumbricoides* infertile egg**	90 µm x 40 µm. Range, 85-95 µm x 35-45 µm.	Elongated, occasionally triangular, kidney shaped or other bizarre forms. Shell often very thin.	Mamillated covering attenuated or missing in many cases.

Source: Based on sizes of eggs in human fecal specimens reported by Harinasuta and Kruatrachue (1962) and Taylor and Moose (1971)

Categorization of whether light. Moderate or heavy infection was used to help in getting the intensity of helminths and schistosomes on the basis of threshold concentration of faecal worm eggs load (Montressor *et al*, 2002). The below table six below shows the threshold for soil-transmitted helminths and schistosomes.

Table 6: Threshold for light, moderate and heavy infections with STH and Schistosomes

Helminth	**Intensity Threshold**		
	Light	**Moderate**	**Heavy**
A. lumbricoides	1 – 4999 epg	5000 – 49999 epg	≥ 50000 epg
T. trichiura	1 – 999 epg	1000 – 9999 epg	≥ 10000 epg
Hookworms	1 – 1999 epg	2000 – 3999 epg	≥ 4000 epg
S. mansoni	1 – 99 epg	100 – 399 epg	≥ 400 epg
S. haematobium	1 – 50 eggs/10ml urine	-	≥ 50 eggs/10ml urine

Source: Adopted from a WHO report of 2002 on helminth control in school age children

3.9 Data Collection

The quantitative research method was used for data collection. Data collection instruments in English language were prepared first. This was followed by training of the research assistants who were within the study area and lab technologists. The data collection tools were pre-tested in the neighbouring primary schools with almost similar characteristics and with heads of the household within the location to validate the tools and estimate how long it took to administer the tools Pre-tested questionnaire and observation checklist based on the risk factors associated with soil-transmitted helminths were developed and modified then used to collect data on socio-demographic and economic characteristics; water, sanitation and hygiene; clinical manifestation (abdominal pain, cough and nausea) and impact of soil-transmitted infection (absenteeism) Joint Monitoring Programme (JMP) guidelines of WHO and the United Nation Children's Fund (UNICEF) were used to define water sanitation and hygiene parameters (Kumpel, *et al*, 2016). Data was collected between morning and mid-morning. All the prospective risk factors, variables of helminths and schistosomes belonged to four categories namely; demographic, water environmental sanitation and hygiene (WASH), immunity and socio-economic factor. The principal investigator informed school children who participated in this study the purpose and explained orally to all the subjects together with teachers on how to handle poly pots and avoid contamination of stool specimens Interviewer's schedule was administered to each child whom the sample of stool was collected to derive information on impact of helminth infection, class, sex and age. During sample collection process and examination, standard operating procedures were followed to ensure the test quality and reliability of results. After school children were interviewed, then their parents were further subjected to the interviewer's schedule. Children were well linked to their respective parents.

3.10 Ethical Considerations

The study was conducted after obtaining an ethical clearance from the Institutional Review and Ethics Committee (IREC) of Moi University which approved this study (Approval Number 0001976 issued on 9th November, 2017). Research permit for the study was given by the National Commission for Science, Technology and Innovation (NACOSTI) while research authorization was granted by the Embu County, Mbeere North Sub-County administrative authorities (Medical officer of Health and Director of Education) and the school head teachers.

Formal verbal parental and school administrative consent was sought and also obtained assent from the pupils. Confidentiality of parents and pupils was assured for any information collected. It was explained to them that participation was voluntary. One of the benefits of those found infected with STH and / or *schistosomiasis*, is that they were treated by the Medical Officer of Health using National worm control guidelines.

3.11 Data Management, Confidentiality and Analysis

Checking of data was done on site to ascertain accuracy and compliance before entry in the software. Socioeconomic data were collected using questionnaires, and data entry done using MS excel software, coded, cleaned then imported into the statistical package - STATA version 14.1 (STATA Corporation College Station, TX, USA) for statistical analysis.

All the hard copies of questionnaires used in mining of data was stored under lock and key in a cabinet and the keys kept under the custody of the Principal Investigator (PI). After data analysis and report writing, the soft copy was equally stored in a computer with a password only known to the PI. These efforts of storing data in hard copies and soft copy was aimed at ensuring privacy and confidentiality for the children as far as their registration numbers were concerned as reflected in the consenting documents.

The dependent variable was STH infections, while the independent variables were age, sex of the children, socio-economic status of their parents / guardians, use of water used for drinking, hand washing and latrines both at their respective schools and homes.

The analysis of prevalence considered equal weights per gender and class since the groups were not balanced. The observed prevalence and intensity of intestinal helminth infections and *S. mansoni* as well as socio-demographic variables were calculated by schools and the 95% confidence intervals (CIs) determined using binomial logistic regression and negative binomial regression respectively, taking into account clustering by schools. *P*-values less than 0.05. was considered statistically significant. The following age groups used for purpose of analysis were; 5-10 years and 10-18 years. The significance of the factors associated with the intestinal helminth infections among the children was determined using multivariable logistic regression model reporting the odds ratios at 95% CIs Associated factors were first subjected to possible confounding variables, adjusted using this model. The choice of the model was based on the log likelihood function. The minimum adequate covariates for multivariable analysis were selected using forward step-wise variable selection method which selected covariates with a p-value less than 0.400 in the bivariable model. The choice of p-value of 0.400 was arbitrarily made to increase chance of obtaining the significance of covariate in the multivariable model. Prevalence of intensity was calculated by taking numerator as the total number of positive school children and denominator as the total number of children whose stool samples were examined.

Individual factors included age, gender, wearing shoes in school, untrimmed dirty hand nails, position in class, signs and symptoms and number of days absent in school while household level factors encompassed monthly income, occupation, marital status, water safety, type of latrine and availability of hand washing facility near the latrine, Consequently, school level factors were that the principal investigator and research assistants verified availability, type of latrine and status for cleanliness as well as state of repair, availability of hand washing facility near the latrine, source of water, presence of soap for hand washing.

3.12 Dissemination of findings

Study findings were disseminated to the relevant key county government officials together with the key stakeholders, and the schools board of management drawn from the five primary schools. Venues for the dissemination were the board room, halls and church while presentation by use of LCD, flip charts and marker pens.

CHAPTER FOUR

4.0 Results

4.1 Demographic Information

A total of 184 school children were selected to participate in the study and 182 provided adequate stool sample, demographic and information on impact of soil-transmitted helminths. The data were collected from 182 children aged between five to 18 years with mean age of 10.9 years (standard deviation 3.0 years) from five schools in Muringari location, Embu County. Information on gender was provided for all the children and 93 (51.1%) were female children.

Additionally, data were collected for household heads of the selected children. The majority (71%) of the household heads were fathers. All the schools were fairly represented in the sample at circa 15.4%.

If we were to calculate the same prevalence estimate without adjusting for the school clusters, then we would have the value as: 18.7% (95%CI: 13.8-25.3) which is now a tight confidence interval.

4.1 Prevalence of intestinal infections among school-age children

One type each of soil-transmitted helminth and schistosomes were identified from the one hunderd and eighty-two stool samples collected and analyzed during the study and these were *Trichuris trichiura* and *Schistosoma mansoni.*

The overall prevalence of helminth infection and any other parasite which captured *S. mansoni* infections was 18.7% (95%CI: 8.3-42.1). The confidence interval heavily varied since the binomial regression model used to calculate the infection prevalence accounted for the fluctuations in the school level infection (school clusters). This is because some schools had low prevalence while others had high prevalence.

Overall, the prevalence of *T. trichiura* was 1.1% (95%CI: 0.3-4.3). It was the only STH detected however, the parasitological data collection tool had provision for other parasites if detected in the stool sample and therefore, the prevalence of *S. mansoni* was 18.1% (95%CI: 7.7-42.9) with associated mean intensity of 17 epg (95%CI: 6-48).

In overall, only Rwanjeru and Itururi schools had STH infections of 3.6% (95%CI: 0.5-24.5) and 3.3% (95%CI: 0.5-22.9), respectively. However, for *S. mansoni* infections, Kathigagaceru and Itururi schools showed the highest infections at 43.9% (95%CI: 31.1-62.1) and 23.3% (95%CI: 12.2-44.6), respectively and Rwanjeru showing no *S. mansoni* infections. The two schools whose children had *S. mansoni* infection are situated near Ena River.

Prevalence for any helminth infections among male children was higher than in their female counterparts; male 25.8% and female 11.8%, (proportion test: z = 2.424, p = 0.015) as observed in table seven.

Most of the surveyed children had only light infections for STH 1.1% (95%CI: 0.3-4.3) and *S. mansoni* infections 15.4% (95%CI: 6.3-37.6), with only 1.1% of the children showing heavy *S. mansoni* infections.

Children of age between 5 and 9 years were found to have low infection against *S. mansoni* and any helminth of 13.8 (5.0-37.6) and 13.8 (5.0-37.6) respectively while those with higher age of 10 - 14 years had moderate infection 21.6 (9.6-48.4) and 22.5 (10.8-47.2). These results were different from a study conducted in Babile Ethiopia which revealed that children in lower classes had higher prevalence than those from higher classes. This may be attributed to their adventures nature of the age set and therefore likely to have higher infection. Besides this, children in higher age were predisposed because established control measures focused more on the lower age group of children such as *Malezi Bora*. Table seven below shows the details.

Table 7: Prevalence of intestinal infections among school-age children

Factor	**n (%) [N=182]**	***T. trichiura***	***S. mansoni***	**Any helminth**
Overall	182 (100%)	1.1 (0.3-4.3)	18.1 (7.7-42.9)	18.7 (8.3-42.1)
School				
Gatororoni	34 (18.7%)	0	11.8 (4.7-29.5)	11.8 (4.7-29.5)
Itururi	30 (16.5%)	3.3 (0.5-22.9)	23.3 (12.2-44.6)	23.3 (12.2-44.6)
Karuari	49 (26.9%)	0	8.2 (3.2-20.9)	8.2 (3.2-20.9)
Kathigagaceru	41 (22.5%)	0	43.9 (31.1-62.1)	43.9 (31.1-62.1)
Rwanjeru	28 (15.4%)	3.6 (0.5-24.5)	0	3.6 (0.5-24.5)
Socio-demographic				
Gender				
Male	89 (48.9%)	1.1 (0.2-8.3)	25.8 (11.5-58.3)	25.8 (11.5-58.3)
Female	93 (51.1%)	1.1 (0.1-8.5)	10.8 (3.4-33.6)	11.8 (4.4-31.5)
Age category				
5-9 years	80 (44.0%)	1.3 (0.2-9.8)	13.8 (5.0-37.6)	13.8 (5.0-37.6)
10-14years	102 (56.0%)	1.0 (0.1-8.0)	21.6 (9.6-48.4)	22.5 (10.8-47.2)
Class				
Class 1	15 (8.2%)	0	20.0 (5.2-77.5)	20.0 (5.2-77.5)
Class 2	22 (12.1%)	0	4.5 (0.5-38.1)	4.5 (0.5-38.1)
Class 3	22 (12.1%)	0	13.6 (3.4-54.0)	13.6 (3.4-54.0)
Class 4	23 (12.6%)	0	17.4 (10.1-29.9)	17.4 (10.1-29.9)
Class 5	32 (17.6%)	6.3 (1.4-28.4)	28.1 (14.0-56.5)	31.3 (17.6-55.6)

Class 6	26 (14.3%)	0	19.2 (7.0-53.1)	19.2 (7.0-53.1)
Class 7	23 (12.6%)	0	21.7 (4.5-56.0)	21.7 (4.5-56.0)
Class 8	19 (10.4%)	0	15.8 (4.6-53.8)	15.8 (4.6-53.8)
Household head				
Mother	48 (26.4%)	0	31.3 (12.1-81.0)	31.3 (12.1-81.0)
Father	130 (71.4%)	1.5 (0.4-5.4)	13.1 (6.5-26.4)	13.8 (7.5-25.4)
Others	4 (2.2%)	0	25.0 (5.7-80.0)	25.0 (5.7-80.0)
Parents' education level				
Primary	145 (79.7%)	1.4 (0.3-5.7)	17.9 (6.5-49.2)	18.6 (7.2-48.3)
Secondary	32 (17.6%)	0	18.8 (10.3-34.2)	18.8 (10.3-34.2)
Post-secondary	5 (2.8%)	0	20.0 (4.2-95.9)	20.0 (4.2-95.9)

4.2 Prevalence of mean intensity (epg) and intensity classification of helminth infections among school-age children in five schools

Table eight below shows prevalence of mean intensity and intensity classification of soil-transmitted helminth and intestinal schistosomes. The prevalence of 18.7% for schistosomiasis indicates that these schools fall under moderate-risk area and therefore all children require treatment once every two years as a preventive chemotherapy measure.

High prevalence and / or high intensity

The cumulative prevalence exceeds 70% of the sample and / or the cumulative percentage of moderately / heavily infected individuals exceeds 10% of the sample.

Moderate prevalence and low intensity

The cumulative prevalence of STH is over 50% but less than 70%; the cumulative percentage of moderately / heavily infected individuals is less than 10%.

Low prevalence and low intensity

The cumulative prevalence of STH infections is below 50%; the cumulative percentage of moderately / heavily infected individuals is less than 10%.

Table 8: Prevalence of mean intensity and intensity classification of helminth infection among school-age children

Parasites	Prevalence (%) [95%CI]	Mean intensity epg (95%CI)	Prevalence (%) of light to heavy intensity of infections		
			Light infection	Moderate infection	Heavy infection
T.trichiura	1.1 (0.3-4.3)	1 (0-4)	1.1 (0.3-4.3)	0	0
S. mansoni	18.1(7.7-42.9)	17 (6-48)	15.4 (6.3-37.6)	1.6 (0.5-5.9)	1.1(0.1-8.6)
Any helminth	18.7(8.3-42.1)	-	-	-	-
Any Helminth: These are parasites whose species belong to the class of Trematodes or flukes such as Schistosoma, Clonorchis, Opisthorchis, Fasciola and Paragonimus This therefore why S. mansoni was included.					

4.2: Species of STH infecting school-age children (SAC)

The study found that *T. trichiura* was the only present STH species and its mean intensity was 0.79 epg (95%CI: 0-4) together with *S. mansoni* with associated mean intensity of 17 epg (95%CI: 6-48.

4.3: Age and class of the school children most infected by the STH

Older children (those above 10 years) had higher prevalence, 22.5% (95%CI: 10.8-47.2), than the younger ones who were 10 years and below, 13.8% (95%CI: 5.0-37.6). Children in classes 5 and 7 whose ages range from 10 years to 18 years had their prevalence for any parasites above 20%.

4.4: School-level risk factors associated with the helminth infections

To be able to determine the associated factors for the soil-transmitted helminths infections, bivariable and multivariable logistic regression were used. At school level, several factors were considered that contribute to the infection. These were age group, wearing shoes, dirty hand nails, latrine type and hand washing facility near the latrine. It was necessary to do multivariable logistic analysis after adjusting variables. Child demographic and school-level WASH risk factors associated with either STH or *S. mansoni* infections are outlined in table nine.

For STH infections, only child's gender, age group, and whether they had dirty nails (observed presence of long nails which were dirty, having black or greyish content) were the only non-significant risk factors identified. The risk factor of dirty nails among school children was done by observation. This was similarly done on whether children were wearing shoes, type of latrine and presence or absence of hand washing facility near the latrine. For the *S. mansoni* infections, multivariable logistic regression estimated that female children were significantly less likely to be infected, aOR = 0.21 (95%CI: 0.08-0.56), p=0.002. Similarly, children from schools with hand washing facility installed near ordinary latrines were significantly at less risk of infection, aOR = 0.09 (95%CI: 0.03-0.25), p<0.001. Children from schools where hand washing facility was not available near latrines have higher risk of the infection, aOR = 8.90 (95%CI: 2.16-36.67), p=0.002.

Table 9: Individual level school WASH risk factors associated with intestinal helminth among school-age children

Factors	Risk factors for any STH infections aOR (95%CI), p-value	Risk factors for *S. mansoni* infections aOR (95%CI), p-value
Gender		
Male	Reference	Reference
Female	0.88 (0.05-15.54), p=0.933	0.21 (0.08-0.56), p=0.002**
Age group		
5-9 years	Reference	Reference
10-14 years	0.69 (0.04-11.75), p=0.801	2.14 (0.86-5.36), p=0.103
Wear shoes		
Yes	Omitted	Reference
No	Omitted	1.03 (0.433-2.49), p=0.944
Has dirty nails		
Yes	Reference	Reference
No	1.40 (0.08-24.71) p=0.818	0.75 (0.30-1.89), p=0.546
Latrine type		
Ordinary	Omitted	0.09 (0.03-0.25), p<0.001**
VIP	Omitted	Reference
Hand washing facility near latrine		
Yes	Omitted	Reference
No	Omitted	8.90 (2.16-36.67), p=0.002**

aOR;- Adjusted odds ratio
** Indicates a significant p-value (<0.05)
** Omitted indicates insufficient observations

4.5: Household-level risk factors associated with the helminth infections

To be able to determine the associated factors for the soil-transmitted helminths infections, bivariables and multivariable logistic regression were used. At household level, several factors were considered that contribute to the infection. These were household head, marital status, education level, occupation, source of water, and hand washing facility near the latrine. Similarly, table 10 outlines the household socio-demographic and WASH risk factors associated with any helminth infections.

The results of multivariable logistic regression estimated that children from households with a father as the head were significantly at less risk of the infection, aOR = 0.22 (95%CI: 0.08-0.59) compared to those with a mother as the household head. Other non-significant risk factors were children with household heads doing farming as the main occupation, households with roof catchment as the main source of water, and households with hand washing facility near latrine. Table ten outlines the details.

Table 10: Multivariable analysis of the household level WASH risk factors associated with any intestinal infection among school-age children

Factors	**Risk factors for helminth infections** **aOR (95%CI), p-value**
Household head	
Mother	Reference
Father	0.22(0.08-0.59), p=0.002**
Others	0.75 (0.06-8.92), p=0.821
Marital status	
Married	Reference
Unmarried	0.39 (0.11-1.39), p=0.149
Education level	
Primary	Reference
Secondary	1.18 (0.39-3.61), p=0.769
Post-secondary	1.00
Occupation	
Farmer	2.05 (0.42-9.96), p=0.371
Formal employment	1.00
Not salaried	6.92 (0.67-71.58), p=0.105
Self-employed	Reference
Source of water	
Roof catchment	3.97 (0.19-81.89), p=0.372
Well	1.00
Piped water	Reference
Stream	0.97 (0.40-2.37), p=0.946
Handwashing facility near latrine	
Yes	Reference
No	**1.05 (0.35-3.13), p=0.926**

aOR;- Adjusted odds ratio
** Indicates a significant p-value (<0.05)

4.6: Impact of helminth infection among school-age children

The clinical manifestations were abdominal pain, cough and nausea while absenteeism accounted for 578 child school-days lost cumulatively for children who indicated missing school due to illness. These clinical manifestations among the children under study were likely to have led to the absenteeism. Despite the fact that infection was not high, it demonstrates the effect of such infection in the health of the children.

CHAPTER FIVE

5.0 Discussion

This is the first school-based health survey of risk factors associated with soil-transmitted helminth infections among school-age children in Muringari location. The most prevalent soil-transmitted helminths as observed from several studies were *Ascaris lumbricoides* and *Trichuris trichiura.* This mirrors the ecological conditions, environmental sanitation and hygiene levels of the locality (Siza *et al,* 2015; Ngonjo *et al,* 2016; Arobodor *et al*, 2019 & Boko *et al,* 2019). This showed the importance of subjecting stool sample to laboratory testing using Kato-Katz method or any other sensitive technique for STH and any other parasite detected in the sample. There was limited evidence of associated risk factors of soil-transmitted helminths in Muringari Location.

The prevalence of STH infections varied greatly in different schools. The overall prevalence and intensity of STH infection would be classified into the low risk area category since soil-transmitted helminth infections is below 50% compared to studies reported from other areas in Kenya, and therefore does not pose a serious public health problem. The technique used of Kato-Katz is not sensitive method and therefore might have missed light infection. The study findings may be explained by geographical variations, socio-economic, cultural context of the population as well as time of the study and method used to examine the stool sample. A study conducted in Babile in Ethiopia revealed that the overall prevalence of soil-transmitted helminths was low which is in line with this study (Tadesse *et al,* 2005). This is in contrast with the WHO definition which states that STH is a public health problem when more that 1 % of the population at risk population has infection of moderate or high intensity and its control requires the delivery of one or more public health interventions (WHO, 2012). However, a study conducted on intestinal helminth infections and associated risk factors among school-age children of Bamendjou in Cameroon revealed that the prevalence of soil-transmitted helminths was 13.6% (Ruth *et al,* 2021). Similarly, a study conducted in Malaysia among school children revealed that prevalence of *T. trichiura* was at 84.6% and thus extremely higher than the one found in this study while that of *A. lumbricoides* at 47.6% and hookworm at 3.9% respectively (Ahmed *et al,* 2012). Another study conducted on prevalence, intensity and associated risk factors of soil-transmitted helminth and schistosome infections in Kenya established *T. trichiura* was more prevalent at 3.6% (Okoyo *et al,* 2020). These findings were not far from those of this study. This study was informed by the fact that intestinal worms ranked third and fifth among the top ten diseases and conditions from Kamumu dispensary and Mbeere Sub-County hospital HMIS data respectively. This difference is likely attributed to the school-based deworming against STH during "*Malezi Bora"* initiative conducted in the months of May and October every year. The parasitological tool aimed to collect data for STH and other parasites found in the stool samples.

This study revealed an overall prevalence of *S. mansoni* which was very high although bilharzia was not among the top ten diseases and conditions from the two health facilities and therefore this became an eye opener of a serious infection among the school-age children in this area. The schools located near Ena river, had children with high prevalence of *S. mansoni* as opposed to schools located far from the river. This study finding agrees with one carried out in Ukara Island, Nort-Western Tanzania which revealed that schools that were located along the shores of the lake, had high intensity of infection when compared to those located far away (Mugono *et al*, 2014). Children found infected with *T. trichiura* which was the most predominant soil-transmitted helminth infection and had their schools located away from this river. The mean intensity of eggs per gram was 1 which was far much below that found in a study carried out in Tachgayint Woreda, North-central Ethiopia which was 238.0 EPG (Eyayu *et al,* 2022). A similar study carried in Kakamega showed that the prevalence of *T. trichiura* was slightly lower at 0.82% than that found in this study (Ngonjo *et al*, 2016). This predominant parasite is known to be a bit stubborn in responding to treatment if a child receives only one tablet of albendazole as is the practice (Kihara *et al*, 2007). *T. trichiura* infection is associated with blood loss which mostly leads to iron deficiency, chronic dysentery, iron deficiency anaemia and poor growth rate of children (Stephenson et al, 2000).

The study revealed that there were no *A. lumbricoides*, and hookworm infections among the study population however, *T. trichiura* infections were found. This therefore means that there was no coinfection against STHs in the study area. This is contrary to a study conducted in Nigeria which revealed *Ascaris lumbricoides* infecting more pupils compared to hookworm species and *T. trichiura* respectively (Salawu S. *et al*, 2015). Study conducted in northern Ethiopia found that hookworm infection was more predominant among school children compared to *A. lumbricoides*, and *T. trichiura,* respectively (Alelign *et al,* 2015). Studies conducted in Busia, Kenya (Brooker *et al,* 2000), and Pemba, Tanzania found that children were infected with all the three STH species. *A. lumbricoides* Species were found infecting school children more than hookworms, in a study conducted in Kenya (Ngonjo *et al,* 2016).

This finding of *T. trichiura* species and no other STHs may be an indication of a less contaminated environment with infective larvae due to high latrine coverage at both school and household levels combined with school-based deworming. This agrees with a study finding which showed that presence of this species in the stool samples examined is likely to be because the cure rate for single dose albendazole is low as this is the practice for school-based deworming (Vercruysse *et al,* 2011). There is need to consider more effective treatment regimen for *T. trichiura.*

Majority of the schistosomes infections were *S. mansoni* in four schools although the study focused more on STH but had room for any other parasite detected in the stool samples. The Kato-Katz method was such a useful method because it was able to assist the researcher identify parasites that were not initially thought for due to the type of data available by then in the health facility. This was informed by previous studies which indicated *S. mansoni* which causes schistosomiasis occurs in central and western part of Kenya (Chadeka *et al,* 2019 & Mwandawiro et al, 2019) and data from Kamumu dispensay. However, children from Kathigagaceru and Itururi schools had heavier schistosomes infections of 18.7% which according to WHO classification falls into moderate prevalence since it is over 10% but less than 50%. Heavy schistosome infections can result to fever, lymphadenopathy and granuloma formation as well as lesions of the liver, portal vein and spleen (Oliveda *et al*, 2014). As a rule, it is postulated that 20% of the population harbours about 80% of the worm population.

A study conducted in Babile, Ethiopia revealed high prevalence of *S. mansoni* in boys than in girls depicting similar findings of this study (Tadesse *et al,* 2005). Similarly, another study conducted in Mwea, Kirinyaga showed that males had slightly higher odds of infection as compared to females (Njambi *et al,* 2020). The observation is supported by the fact that boys have affinity for swimming due to their playful behaviour than girls and this may expose them to water bodies with larval stage which is infective (Masaku *et al,* 2015). A study conducted in Lurambi, Kakamega, Kenya revealed that children who were swimming in rivers were 13.13 times more likely to be infected with soil-transmitted helminths and *Schistosoma. mansoni (*Kiiti *et al,* 2020).

Similarly, a study conducted in Kakamega County, in the Western region of Kenya among school children showed that prevalence of *A. lumbricoides* at 43.5% to be very high followed by hookworm at 0.27% and *T.trichiura* at 0.83% respectively. The prevalence of *T. trichiura* was almost that found in this study. The observed prevalence of *S. mansoni* was similar to findings in a study carried out in Mwea, Kirinyaga among school-age children on drug efficacy of deworming medicines which showed the prevalence of 18.6% for *S. mansoni* and 0.6% for *T. trichiura* (Kihara *et al,* 2007). Another study conducted in Mwea irrigation scheme, Kirinyaga (Njiru *et al,* 2016) revealed that prevalence of *S. mansoni* was 17.3%, which is not far from the finding of this study. Muringari Iocation where the study was conducted in Mbeere North, and Mwea in Mwea East are common in that they are characterized by hot and dry semi-arid zones. Muringari has low annual rainfall of less than 600 mm while Mwea is below 750 mm. Muringari and Mwea are located at an elevation of 1,033 and 1,175 meters above sea level, respectively (Fausta *et al,* 2018). However, another study carried out in Eastern region, Kenya on *S. mansoni* found a prevalence of 2.4% which was far much lower than the findings of this study (Okoyo *et al,* 2020).

This study showed that majority of school-age children infected with *S. mansoni* were males as compared to females. Accordingly, a study conducted in South Eastern Ethiopia made similar observations (Tulu, *et al,* 2014). This agrees with a study conducted in Mbita, Western Kenya which revealed that males had higher infections as opposed to females probably due to their adventurous nature (Nagi *et al*, 2014).

The odds of STH and *S. mansoni* infection was greater among children aged above 10 years than those aged 10 years and below. Children are exposed to infection as early as at 6 months of age and maximal infection and severity occurs in early childhood (10-14 years) followed by a progressive decrease according to study conducted in Brazil, A study conducted in Northern Ethiopia showed that the odds of STH infection were greater among school children of 10-14 years old than those of lower age cohorts (Alelign *et al,* 2015). This means then that the 10-14 years old children are prone to STH and *S. mansoni* infection compared to the younger children due to their playfulness in any environment. Conversely, these findings do not agree with studies conducted in Nepal which revealed a prevalence of STH being highest among children of 6-10 years old (Chandrasekhar *et al*, 2005) and in Nigeria among age group 8-9 years then 13-14 years old children (Salawu *et al*, 2015). This trend of high prevalence among children aged 10 years and above agrees with observations of a study conducted in Osun State of Nigeria (Sowemimo & Asaolu, 2011). This high prevalence could be attributed by the fact that children of this age are not oblivious of the type of environment under which they play affecting their health adversely. Their behaviour on self-discovery is very high at this age and copying what older children and adults are doing as well. Their behaviour on hygiene is quite wanting and will eat without washing their hands after playing in contaminated environments whereas parents of children younger than 10 years are a bit keen on washing their hands and also cautioning them against playing in contaminated areas. Children above ten years of age are involved in household activities, farming and even outdoor recreational activities which brings them to water bodies, which are likely to be infected (M'Bra *et al,* 2018). Similarly, another study conducted in Western Kenya observed that prevalence went high as age increased particularly during the adolescence stage (Kiiti *et al*, 2020). A similar study conducted in Kisumu, Kenya showed a prevalence of 13% for *S. mansoni* which was slightly lower than that found in this study (Sang, *et al,* 2014). Another study conducted in Coastal region, Eastern and North Eastern regions revealed a prevalence of 2.2% for *S. mansoni* with the mean intensity of 12 eggs per gram which was lower than that found in this study (Okoyo, *et al*, 2020).

Households that were headed by fathers had children with low infections as compared to those headed by ladies. This is likely to be that fathers limit their children access to outside as opposed to mothers who are usually accompanied to the gardens, rivers, markets and fetching field by their children. Children in class 6 and 7 had low prevalence. This could be attributed by the fact that as they get older, their behaviour on where and how they play in the environment is well chosen as they have entered the middle adolescent stage. This agrees with observations of studies conducted by various authors (Adanyi *et al*, 2011). However, these results do not agree with study conducted in Kakamega which showed that children aged four to five years had the highest prevalence of helminths at 67.5%. Nonetheless, the mean intensity for helminths was higher among children aged six to seven years and those aged twelve to thirteen years old respectively (Ngonjo *et al*, 2016).

Rainwater harvested from galvanized iron sheet roofs is an alternative method for improved water source at school and household for drinking and other uses. Roof catchment was found to be the main source of water at the household level. It was not associated with STH infection among children in the current study. This is likely to be due to its indirect nature of STH transmission through water as their larvae longevity in water is decreased.

The interviewers were able to verify the type of latrines physically at the school level though at the household level they depended on what was reported by the head of the household. Children from schools with ordinary latrines were significantly at less risk of infection. Majority of head of households reported using ordinary pit latrines. This therefore means that there was improved sanitation at both school and household levels which ended up in reduced soil contamination with infective eggs. Of all the schools visited, none lacked latrines, were in good state of repair and not soiled. However, majority had ordinary latrines compared to VIP latrines which therefore were the reference. None of the schools had traces of open defaecation, meaning that contact levels to excreta may not have been there and if any then was minimal.

Majority of children wore shoes minimizing levels of infection particularly by hookworms. Almost all children from all the five primary schools had shoes which was protective to hookworm infection. Lack of shoes was not therefore a risk factor for the STH but for *S. mansoni* infection. This agrees with a study conducted in Delhi, India which revealed that behavioural factor such as children walking to and out of school without shoes were not found to be significant on multivariate analysis. This also agrees with a study conducted in Northern Ethiopia which revealed that school children who did not wear shoes (Adjusted Odds Ratio - aOR = 2.24) had higher probability of infection with *S. mansoni* than those who wore shoes (Alelign *et al,* 2015). Similarly, another study conducted in Tachgayint Woreda, North-central Ethiopia, found that children who did not wear shoes were 4 times more likely to be infected with soil-transmitted helminths than those who wore on regular basis (Eyayu *et al*, 2022). This equally agrees with another study conducted in five regions of Kenya which revealed that majority of school children at 84.5% were wearing shoes during the time of the study (Okoyo *et al,* 2020). Similarly, this agrees with study findings conducted in Lurambi, Kenya which showed that wearing of shoes had regression coefficient below zero meaning that the risk factor checked out was a protective factor (Kiiti *et al*, 2020). Wearing of shoes, absence of hand washing facility near latrine at both school and household levels were not associated with STH infection among school children. This is likely to mean that majority of children do not wash their hands after visiting toilets which is a risk factor predisposing them to infection. Hand washing with soap was shown to be protective against *A. lumbricoides* through systematic review (Cairncross, 2009). This finding is in contrast with a study which showed that these risk factors were associated with increased odds of STH infection (Alelign *et al*, 2015).

Children with long nails with dirt were among those identified as a risk factor not associated for STH infections. A study conducted in Delhi, India on multivariable logistic regression analysis on nail hygiene among school-age children found similar findings with this study (Gupta *et al*, 2020). Children of this age are not likely to keep such long nails clean and therefore contaminated. This does not agree with study findings which showed that distribution of STH is influenced by factors such as poor environmental sanitation, lack of personal hygiene (Nasr *et al*, 2013).

This study found that children were absent from school for many days as observed in the class register on absenteeism and probably contributed by soil-transmitted helminth and *S.mansoni* infections. Similarly, a study conducted in five regions, Kenya revealed that absenteeism from school for more than two days was significantly associated with increased odds of soil-transmitted infection (Okoyo, *et al*, 2020). This study is in line with another one conducted in Malaysia which postulated that absenteeism was associated with A. *lumbricoides* and hookworm infection. However, *T. trichiura* infection had no association with absenteeism (Ahmed, et al, 2012).

The study did not find any association of socioeconomic status of the head of the household in terms of how much they earned with STH infection of the children sampled. This contradicts a study which showed that STHs are influenced by poor socio-economic conditions including and not limited to low family income (Brooker *et* *al*, 2004). Similarly, this also contradicts a study which revealed that soil-transmitted helminths infections are influenced by socioeconomic level (Kiiti et al, 2020)

Study Limitations

The Kato-Katz technique used to detect eggs of STH and schistosomes has a lower sensitivity. However, FLOTAC has a higher sensitivity. Information on WASH at home was self-reported by parents and not directly collected or observed, this may be biased and deceptive compared to observing.

CHAPTER SIX

Conclusion and Recommendations

6.0: Conclusion

1. The prevalence of STH infections was low at 1.1%, however, it was high for *Schistosoma mansoni* at 18.1%.

2. The impact of helminth infections was significant with high numbers of school days lost contributed by clinical manifestations probably due to *T. trichiura* and *S. mansoni* infections.

3. Risk factors associated with STH and *S. mansoni* infections were young children, female pupils, absence of hand washing facility near the latrine and female headed households.

6.1: Recommendations

1. The prevalence of *S. mansoni* was high and therefore need for the Sub-County Medical Officer of Health, Mbeere North to facilitate treatment of school-age children against *schistosomiasis* in line with WHO worm control guidelines.
2. The impact of helminth infections contributed to man-days of school attendance lost by children on education and therefore needs to be explained to the entire community.
3. Intensify health education among school children and community on risk factors associated with STH infection, health and education fraternity on effect of swimming in the infested Ena river.

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Appendices

Appendix I: Questionnaire for the pupil

Parasitological and Demographic Data

Name of primary school………………………………Date…....................

Location……………………………………………….

ID/Number……… Class……… Sex……… Age………… years

Stool Examination	Eggs per Slide A B
Ascaris lumbricoides	
Hookworms	
Trichuris trichiura	
Other parasites ………………….. …………………..	

Observation Check list at the School Level

I. Water, Sanitation and Hygiene

1. Is the child in shoes?

   Yes [ ]

   No [ ]

2. Presence of untrimmed dirty hand nails

   Yes [ ]

   No [ ]

3. The main source of water at school

Roof catchment [ ]

Well [ ]

Piped water [ ]

Stream [ ]

None [ ]

4. Type of latrine

Ordinary latrine [ ]

VIP latrine [ ]

Others (Specify)…………………….

5. General status of latrine

Boys	**Ordinary latrine**	**VIP latrine**	**Others (Specify)……Number of doors.......**
Cemented	………………...	…………..	…………
Clean	…………………	…………..	…………
Soiled	…………………	…………..	…………
Full	…………………	…………..	…………

Girls	**Ordinary latrine**	**VIP latrine**	**Others (Specify)……Number of doors.......**
Cemented	………………	…………..	……………
Clean	………………	………….	……………
Soiled	………………	………….	……………
Full	………………	………….	……………

6. Hand washing facility near the latrine

   Yes [ ]

   No [ ]

7. Presence of soap for hand washing

   Yes [ ]

   No [ ]

II Impact of helminth infection

8. Position in class on performance of exam previous term

9. What signs and symptoms of disease are you experiencing?

10. How many days were you absent from school because were feeling unwell?

Appendix II: Questionnaire for the Head of the Household

I. Socio-demographic Data

1. Head of the household

Mother [ ]

Father [ ]

Grandfather [ ]

Grandmother [ ]

Others (Specify)……………………..……

2. Marital status of the head of household

Married [ ]

Not married [ ]

Separated [ ]

Divorced [ ]

Widowed [ ]

3. Level of education of the head of household

Primary [ ]

Secondary [ ]

Tertiary [ ]

University [ ]

None [ ]

4. Occupation of the head of the household

Farmer [ ]

Self-employed [ ]

Formal employment [ ]

Unemployed [ ]

5. What is the monthly income of the head of the household in Ksh?

Less than Ksh. 5,000

Ksh. 5,000- 10,000

Ksh. 10,000- 20,000

Over Ksh. 20,000

II. Water, Sanitation and Hygiene

6. What is your main source of water at home?

Roof catchment [ ]

Well [ ]

Piped water [ ]

Stream [ ]

None [ ]

7. Do you do anything to make water safe?

   Yes [ ]

   No [ ]

8. If yes, what do you do?..

9. Do you have a latrine at home?

   Yes [ ]

   No [ ]

10. If yes, what type of latrine? ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,

11. When do you wash your hands?

   Before eating [ ]

   After eating [ ]

   After handling dirty items [ ]

   After visiting latrine [ ]

   Others (Specify)………………………….

12. Do you have hand washing facility near the latrine?

   Yes [ ]

   No [ ]

Appendix III: Participant Information Sheet

Title of Study: 'Risk Factors Associated with Soil Transmitted Helminth Infections among school-age children in Muringari Location, Mbeere North Sub-County, Embu County, Kenya'.

Introduction

You are asked to participate in a public health research on Soil Transmitted Helminth Infections. The Soil transmitted helminth are major public health concerns in the sub-Saharan Africa (SSA) region. Some of the factors predisposing humans to the infections are use of unsafe water, poor environmental sanitation and hygiene. STH infections are more prevalent among school-age children (5-14 years) in developing countries. The World Health Assembly delegates endorsed a resolution urging endemic countries to start seriously tackling soil-transmitted helminth. The strategy for control of STH infections is to control morbidity among the people at-risk living in endemic areas such as the school-age children among others. However, this should be preceded by establishing the prevalence of STH, and identifying the risk factors to guide effective prevention and control strategies. The purpose of this information sheet is to give you details of the proposed research so as to help you decide whether to participate or not. You are allowed to ask questions related to the study and implications on your part.

Purpose of the study

To find out whether the roundworm, the whipworm and hookworm species under investigation are the STHs infecting the children and the proportion infected. Whether age, water, sanitation, hygiene and socioeconomic status of the head of household are the risk factors associated with STH infection among the school-age children. The results of this study will provide the state department of Health at the County level in collaboration with the Ministry of Health at the national level with information that might become useful when designing prevention and control programme.

Procedures to be followed

The study team will ask the children through their parents/guardians and the head teacher to give a stool sample contained in the poly pots. The stool samples will be examined for the Soil Transmitted helminth in the laboratory at Kamumu dispensary. The questionnaires will be administered to gather socio-demographics information among other characteristics from your children and you (the parents/guardians).

Why have I been chosen?

The community was chosen because data from Kamumu dispensary on the top ten diseases/conditions indicated that intestinal worm infection is ranked third. The five public primary schools randomly selected within the community through the pupils and their parents/guardians will help in estimating the infection, proportion and risk factors associated with the infection.

Risks

The risks expected from being in the study is none because it will involve testing of stool samples and therefore “Less Likely”.

Benefits

The possible benefits to you from this study are deworming by the state department of health at the County level and the Ministry of Health at the national level respectively, if found infected with the soil transmitted helminth. Coupled with other prevention and control strategies, this will result in improving health and academic performance.

The possible benefits to society may include establishing school based parasite control programme in all the primary schools in Muringari location.

Assurance of confidentiality

Your name and other records will remain under lock and key in a cabinet and in a computer only accessible through a password to ensure confidentiality and will not appear when we present this study or publish its results in any journal.

Storage of specimens

After completion of the laboratory tests related to this study, a unique number without your name will be used to label the specimens to maintain confidentiality.

Right to refuse or withdraw

It is important that you understand the following general principles that will apply to all participants in the study:

1. Your participation (or your children) is entirely voluntary.
2. You may withdraw from this study any time without penalty or loss of benefits.

Please feel free to ask any questions that you may have.

Contact information

If you have questions in the future related to this study, please contact the Principal Investigator, Erastus Ngari Karani, Neonatal, Child & Adolescent Health Unit, Division of Family Health, Ministry of Health, Afya house, P. O. Box 43319-00100, Nairobi, cellphone number +254706560669, email: nyangwa64@gmail.com who will respond to questions raised.

Part 1 - Consent Form for Persons Aged 18 Years and Above

Title of Study: 'Risk Factors Associated with Soil Transmitted Helminth Infections among school-age children in Muringari Location, Mbeere North Sub-County, Embu County, Kenya'.

I acknowledge that this study has been fully explained to me in a language that I understand and I voluntarily agree to participate. I have understood all that has been read and had my questions answered satisfactorily. I understand that participation is voluntary and I am free to withdraw at any time, without giving any reason, without medical care or legal rights being affected. I understand that there is monetary compensation for participation at Ksh. 400/=.

☐ **Yes** ☐ **No** *please tick* **I agree to participate/allow my child to take part in this research**

☐ **Yes** ☐ **No** *please tick* **I agree to stool samples being taken from my child for analysis**

☐ **Yes** ☐ **No** *please tick* **I agree to respond to socio-demographic and economic questions**

Participant's signature or mark: _____________________________ Date ____________

I certify that I have followed all the study specific procedures described in the SOP for obtaining informed consent.

Designee/investigator's signature:_________________________Date ____________

Designee/investigator's name: ______________________________Time ____________

(Please print name)

Only necessary if the participant cannot read:

I *attest that the information concerning this research was accurately explained to and apparently understood by the participant and that assent was freely given by the participant.

Witness' signature: ______________________________________ **Date** _____________

Witness' name: ______________________________________ **Time** ______________

(Please print name)

*A witness is a person who is independent from the trial or a member of staff who was not involved in gaining the consent.

Part 2 - Consent Form for Persons Below 18 Years

Title of Study: 'Risk Factors Associated with Soil Transmitted Helminth Infections among school-age children in Muringari Location, Mbeere North Sub-County, Embu County, Kenya'.

I, being a parent/guardian of **_________________________________** (name of child), have had the research explained to me. I have understood all that has been read and had my questions answered satisfactorily. I understand that participation is voluntary and I [and my child] are free to withdraw at any time, without giving any reason, without medical care or legal rights being affected. I understand that there is no monetary compensation for participation.

□ **Yes** □ **No** *please tick* **I agree to allow my child to take part in this research**

□ **Yes** □ **No** *please tick* **I agree to stool samples being taken from my child for analysis**

□ **Yes** □ **No** *please tick* **I agree to respond to socio-demographic and economic questions**

Parent/guardian's signature or mark: **_______________________Date ___________**

I certify that I have followed all the study specific procedures described in the SOP for obtaining informed consent.

Designee/investigator's signature: ________________________ Date ____________

Designee/investigator's name: ______________________________Time ____________

(Please print name)

Only necessary if the parent/guardian cannot read:

I *attest that the information concerning this research was accurately explained to and apparently understood by the parent/guardian and that informed consent was freely given by the parent/guardian.

Witness' signature or mark: _________________________ Date _____________

Witness' name: **__________________________________Time ______________**

(Please print name)

*__A witness is a person who is independent from the trial or a member of staff who was not involved in gaining the consent.__

The parent/Guardian Should now be Given a Signed copy to Keep.

Part 3 – Child Assent Form (For Minors Aged Below 18 yrs)

Title of Study: 'Risk Factors Associated with Soil Transmitted Helminth Infections among school-age children in Muringari Location, Mbeere North Sub-County, Embu County, Kenya'.

Child or if unable to write, parent/guardian on their behalf to circle all they agree with:

Has somebody explained this study to you?	Yes/No
Have you had your questions if any answered in a way you understand?	Yes/No
Do you know that you can to stop taking part at any time?	Yes/No
Do you know that you will give stool samples?	Yes/No
Can you allow us to record your medical history?	Yes/No

If <u>any</u> answers are 'no' or you **don't** want to take part, **don't** sign below!

☐Yes, I do consent – I hereby agree to take part in this study.

☐No, I do not consent – I do not wish to take part in this study.

Child's signature or mark: ______________________________ Date _____________

I certify that I have followed all the study specific procedures described in the SOP for obtaining informed consent.

Investigator's signature: ______________________________ Date _____________

Investigator's name: _______________________________Time _____________

(Please print name)

Only necessary if the parent/guardian cannot read:

I *attest that the information concerning this research was accurately explained to and apparently understood by the child and that assent was freely given by the child.

Witness' signature: _______________________________________ Date ______________

Witness' name: _______________________________________ **Time ______________**

(Please print name)

***A witness is a person who is independent from the trial or a member of staff who was not involved in gaining the consent.**