INFECTIONS WITH INTESTINAL PROTOZOA AND GHOHELMINTHS AND THE RISK FACTORS AMONG SECONDARY SCHOOL STUDENTS IN MAARA SUB-COUNTY, THARAKA-NITHI COUNTY, KENYA

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REG. NO; I56/CE/22425/2010

A thesis submitted in partial fulfillment of the requirements for the award of the degree of Master of Science (Applied Parasitology) in the School of Pure and Applied Sciences of Kenyatta University

October, 2016
DECLARATION

This thesis is my original work and has not been presented for a degree in any other university or for any other award.

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Declaration by supervisors;

We confirm that the work reported in this thesis was carried out by the candidate under our supervision and that it is submitted for examination with our approval.

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DEDICATION

I dedicate this work to my daughter Audrey Amani whose motivation and encouragement enabled me to complete this course.
ACKNOWLEDGEMENT

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I wish to thank the Principal and students of Muthambi Girls Secondary, Kajiunduthi, Kyeni Day and Munga Secondary schools for accepting to have this study conducted in their schools. Special thanks go to all the students in the named schools, for participation in the study by providing stool samples and filling questionnaires.

My heartfelt gratitude goes to Dr. Kenneth Micheni for allowing me to use Bethsaida hospital laboratory and the technical staff. I am also grateful to Mercy Gatwiri and Purity Gacheri who assisted me in analysis of stool samples.

I will forever remain grateful to my husband Mr. James Njeru whose effort and assistance made all this work possible.
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<tr>
<td>CBS</td>
<td>Central bureau of statistics</td>
</tr>
<tr>
<td>CDC</td>
<td>Centre for disease control</td>
</tr>
<tr>
<td>ELISA</td>
<td>Enzyme Linked Immunosorbent Assay</td>
</tr>
<tr>
<td>EPG</td>
<td>Eggs per gram</td>
</tr>
<tr>
<td>IFAT</td>
<td>Immunofluorescent antibody test</td>
</tr>
<tr>
<td>IHA</td>
<td>Indirect haemagglutination</td>
</tr>
<tr>
<td>KMD</td>
<td>Kenya Metrological Department</td>
</tr>
<tr>
<td>RPM</td>
<td>Rotations per minute</td>
</tr>
<tr>
<td>SSA</td>
<td>Sub-Saharan Africa</td>
</tr>
<tr>
<td>UV</td>
<td>Ultraviolet</td>
</tr>
<tr>
<td>STH</td>
<td>Soil transmitted helminths</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
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### DEFINITION OF OPERATIONAL TERMS

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Anthelminthic</td>
<td>Drugs used to treat helminths infections.</td>
</tr>
<tr>
<td>County</td>
<td>A political administration unit consisting of several districts.</td>
</tr>
<tr>
<td>Endemic</td>
<td>Occurrence of a disease at all times in a place.</td>
</tr>
<tr>
<td>Encyst</td>
<td>Change of trophozoite stage to cyst by enclosing in a cyst wall.</td>
</tr>
<tr>
<td>Geohelminths</td>
<td>Soil-transmitted helminths.</td>
</tr>
<tr>
<td>Hygiene</td>
<td>The promotion of cleanliness to prevent spread of diseases.</td>
</tr>
<tr>
<td>Risk factors</td>
<td>Describes the factors that are positively associated with the development of a disease but are not sufficient to cause the disease.</td>
</tr>
<tr>
<td>Safe water</td>
<td>Drinking water that is boiled, filtered and / or chlorinated.</td>
</tr>
<tr>
<td>Trophozoites</td>
<td>The vegetative or invasive stages of some protozoa.</td>
</tr>
<tr>
<td>Unsafe water</td>
<td>Water that is neither boiled, filtered and / or chlorinated</td>
</tr>
</tbody>
</table>
Intestinal parasitic infections caused mainly by protozoa and helminths are most prevalent in tropical and subtropical regions of the world where adequate water and proper sanitation are lacking. Helminthiasis has been listed among the three most prevalent diseases in Tharaka-Nithi County. The residents are mainly small scale non-mechanized farmers hence there is frequent contact with the soil. Chronic parasitic infection among students negatively affects their health, nutrition, cognitive development, and educational achievement. Research, treatment and control efforts have been focused largely in primary schools, while neglecting secondary schools. These interventions in primary schools have been shown to improve students’ health and academic achievements. Secondary school students potentially play a major role in transmission of intestinal parasites to entire populations since they originate from different regions of the country. The findings would enable the health sector establish programs to control intestinal parasitic infections among secondary school students and entire populations, hence improve their health. This study aimed at determining the occurrence of intestinal parasites among Form one, two and three students in four randomly selected public secondary schools both day and boarding in Maara Sub-County in Tharaka-Nithi County, Kenya. Faecal specimens were collected in May 2013, from 384 students, both male and female. The specimens were processed by direct wet mounts and concentration technique, and then examined microscopically to determine the presence and intensity of intestinal parasites. Chi square ($\chi^2$) test was used to predict association between infection rates with age, sex and school type. The difference was considered statistically significant at p-value $\leq$ 0.05. Structured questionnaires were used to collect data on transmission risk factors of intestinal parasites which were compared using adjusted odds ratio (aOR). The intestinal parasitic infection rate was 36.2%, of which 19.0% and 17.2% were due to protozoa and helminths respectively. The most commonly identified intestinal parasites were *A. lumbricoides* (10.4%), *E. histolytica* (16.9%), hookworms (3.9%), *T. trichiura* (2.9%), and *G. lamblia* (2.8%). More males (39.6%) than females (33.2%) were infected though the difference was not statistically significant ($\chi^2=3.92$ p=0.56, df=2). Kyeni Day school had the highest infection rate (42.2%) while Kajiunduthi had the least (32.8%). The parasitic infection rates were significantly higher in day schools (40.6%) compared to boarding schools at 34% ($\chi^2=249$ p=0.00, df=2). Majority of the students (96.4%) had single species infections while 3.6% had multiple protozoa and helminths infections. The co-infection rate of protozoa and helminths in day and boarding schools was statistically different ($\chi^2=15.14$, p=0.004, df=4). Most of the helminths infections among students (56.1%) were of light intensity while 25.8% were of heavy intensity. The infections were associated with involvement in farming activities (OR=3.07, CI=2.19-4.32) and water sources (OR=4.02, CI=2.57-6.92). The personal hygienic factors associated with intestinal parasitic infections were failure to boil drinking water (OR=3.3, CI=0.19-5.6), failure to wash hands with soap (OR=2.96, CI=2.07-4.21), failure to wash fruits before eating (OR=5.8, CI=3.82-8.94) and failure to wear shoes (OR=2.54, CI=1.87-3.45). This study concluded that there was high level of intestinal parasitic infections among the secondary school students with associated transmission risks. It is recommended that health education on personal hygiene and environmental sanitation be adopted in secondary schools in order to reduce intestinal parasitic infections among students. The County medical services should conduct deworming programs in secondary schools once every three months together with screening and treatment of protozoa infections.
CHAPTER ONE

INTRODUCTION

1.1 Background information

Parasites related to human gastrointestinal tract are the major causes of health burden in many nations especially in the developing world. These can be categorized into two groups; protozoa and helminths. The most common are soil-transmitted helminths (STH) which include; Ascaris lumbricoides, hookworms (Ancylostoma duodenale and Necator americanus), Trichuris trichiura, Strongyloides stercoralis and Enterobius vermicularis. The helminths are multicellular organisms that are associated with depletion of nutrient of the host for their own nutrition. They are so called because humans become infected through contact with soil that has become contaminated with parasites through poor human behavior of excrete disposal. Protozoa are unicellular parasites that are associated with damage of intestinal mucosa resulting in malabsorption of nutrients leading to diarrhoea and dysentery. The most common pathogenic protozoa are Giardia lamblia, Entamoeba histolytica, Balantidium coli, and Cryptosporidium (Chiodine et al., 2001). Protozoa are mainly transmitted to human through protozoa-contaminated and insufficiently prepared food and water. There are many other non-pathogenic protozoa that are found in intestinal canal whose presence indicates faecal-oral contamination in poor sanitary environment and poor hygiene practices.

It is estimated that 1.5 billion people or 24% of the world’s population are infected with intestinal parasites (WHO, 2014). While whole populations are geographically at risk, children are observed to disproportionately carry the greatest burden of infection
(Harhay et al., 2010). Over 270 million pre-school age children and over 600 million school-age children live in areas where these parasites are intensely transmitted hence are in need of treatment and preventive interventions (WHO, 2011). Parasitic infections are a major public health problem in developing countries because of poor social economic conditions, poor sanitation and improper hygienic practices. They cause iron deficiency anaemia, growth retardation, intestinal obstruction in children and other physical and cognitive development problems (Pinar et al., 2004). This hinders their academic achievement and slows down the rate of economic development (WHO, 2010). Students are active in unsanitary environment and rarely employ good sanitary behavior (Gambao et al., 2003). These potential carriers are often crowded together for long periods of time for example, in schools. Most secondary schools in Kenya admit students from all parts of the country most of which lack adequate water supply. The students potentially transfer infections between the school and home environments hence playing a major role in transmission of infections among entire populations.

1.2 Statement of the problem

Poor access to safe water supply and hygiene are important risk factors for transmission of intestinal parasites (WHO, 2011). In Maara Sub-County, most of the schools do not have safe drinking water, and there is widespread use of pit latrines as opposed to flush toilets. Poor sanitation and hygiene in pit latrines use could contribute to transmission of intestinal parasites especially due to infestation with flies which are mechanical carries of parasites eggs and cysts (Okyay et al., 2010). Secondary school students participate in farming activities after school and during school holidays thus increasing chances of getting infected through ingestion of helminths eggs and / or protozoa cysts due to poor personal hygiene. The students are
also involved in handling of food in homes hence if proper hygiene is not practiced they are likely to transmit infections to other people. Most of the earlier studies have focused on primary school children with limited data on secondary school students. Secondary schools in Tharaka-Nithi County admit Form one students from all over Kenya and there are chances that such students are already infected thus may introduce new infections to the school environment. Epidemiological studies have shown that intestinal parasitic infections among secondary school students may adversely affect their health and academic achievements (Shreshtha et al., 2012). In addition the students can potentially transmit infections to other students in school and to people at home. This study was aimed at determining the occurrence of intestinal parasitic infections among secondary school students in Maara Sub-County in Tharaka-Nithi County. This will involve them in control efforts aimed at improving their health. Such data could boost the efforts in controlling intestinal parasitic infections among entire populations.

1.3 Study justification

Intestinal parasitic infections are endemic in various parts of Kenya (Thion’o et al., 2009). These infections are more common in institutions where there is inadequate water supply and proper hygiene is not practiced (Cappello, 2004). In most secondary schools of rural Kenya there is inadequate water supply (CBS, 2001) hence students are at a risk of intestinal parasitic infections. Tharaka-Nithi County residents are mainly small scale non mechanized farmers (CBS, 2001) hence there is frequent contact with the soil increasing chances of acquiring STH. Helminthiasis is listed among the three most common diseases together with malaria and typhoid in the County. The County has both day and boarding secondary schools that admit students from all parts of Kenya. These may introduce parasitic infections into the school
environment due to unsanitary behavior or with soil contaminated with helminths eggs on their shoes. Students hardly practice proper hygiene hence increasing chances of ingestion of helminths eggs (Brooker and Clement, 2009). The current study therefore aimed at providing data on the occurrence levels of intestinal parasites among secondary school students in Tharaka-Nithi County as an indicator of the prevailing situation in majority of schools in rural Kenya. The study established the risk factors associated with the transmission of intestinal parasites among the students and has provided recommendations on intervention strategies to curb the problem in schools with the aim of improving students’ health.

1.4 Research questions

i. What is the infection level by intestinal protozoa and geohelminths among students in secondary schools in Maara Sub-County, Tharaka-Nithi County, Kenya?

ii. What are the levels of co-infections with intestinal protozoa and geohelminths among students in secondary schools in Maara Sub-County?

iii. What are the transmission risk factors associated with intestinal protozoa and geohelminths infections among students in secondary schools in Maara Sub-County?

1.5 Null hypothesis

i. The infections with protozoa and helminths are not prevalent among secondary school students in Maara Sub-County in Tharaka-Nithi County in Kenya.
ii. There are no human and environmental factors associated with transmission of intestinal parasitic infections among secondary school students in Maara Sub-County.

1.6 General objective
To determine the infection levels with intestinal protozoa and geohelminths and the risk factors among students in public secondary schools in Maara Sub-County in Tharaka-Nithi County, Kenya.

1.7 Specific objectives
i. To determine the occurrence levels of protozoa and geohelminths among secondary school students in Maara Sub-County.

ii. To determine the levels of co-infections with geohelminths and intestinal protozoa among students in secondary schools of Maara Sub-County.

iii. To determine the human and environmental factors associated with infection by intestinal parasites among students in secondary schools in Maara Sub-County.

1.8 Significance of the study
National programs for eradication of parasitic diseases targets school age children in primary school and little or no attention is given to students in secondary schools. The data in this study proves that the secondary school students are also at risk of acquiring and transmitting intestinal parasitic infections in Maara Sub-County in Tharaka-Nithi County. The findings are useful to the health sectors and would enable them to establish programs to control intestinal parasitic infections among secondary school students and entire populations. Such measures should enhance the health status of students.
CHAPTER TWO

LITERATURE REVIEW

2.1 Overview on intestinal parasites

Intestinal parasites of different species of helminths and protozoa inhabit the gastrointestinal tract of humans especially in the tropics where sanitation and hygiene are poor (WHO, 2011). Geohelminths are transmitted to human through his interaction with contaminated soil in his daily activities. Intestinal helminths are classified into three major groups; nematodes such as *Ascaris lumbricoides* and hookworms (*Ancylostoma duodenale* and *Necator americanus*), *Strongyloides stercoralis*, *Trichuris trichiura* and *Enterobius vermicularis*. Common trematodes include *Schistosoma* (*Schistosoma haematobium*, *Schistosoma japonicum*, *Schistosoma masoni*) and cestodes such as *Taenia solium*, *Taenia saginata* and *Hymenolepis nana* (De silva *et al.*, 2003). Intestinal protozoa are mainly categorized into amoebas such as *Entamoeba histolytica*, flagellates such as *Giardia lamblia*, ciliates such as *Balantidium coli* and coccidia that comprise *Cryptosporidium* and *Cyclospora* species (Broeker and Clement, 2009).

The intestinal parasitic infections are widespread in tropical and subtropical regions of developing countries (Cappello, 2004). WHO (2010) estimates proposed that of the then 18.1 million school-aged children in sub-Saharan Africa (SSA), almost half were infected by one or more parasitic helminths. Intestinal parasitic infections are most prevalent in poor segments of populations with low household income, poor personal hygiene, improper environmental sanitation, overcrowding and limited access to safe water (WHO, 2011). Specific occupations, household clustering and behavior influence the frequency and intensity of infections (Hotez *et al.*, 2004), particularly
for helminths in which high intensities of infections occur among adults (Cassio et al., 2003; Capello, 2004).

Amoebic dysentery resulting from *Entamoeba histolytica* is the second most common cause of death from parasitic diseases worldwide after malaria (WHO, 2013). It is estimated that *Entamoeba histolytica* infects 40-50 million people resulting in approximately 100 000 deaths annually (WHO, 2013).

Helminths have three main stages of life cycle; egg, larvae, and adult (Murray et al., 2005). The eggs have tough resistant walls to protect the embryo as it develops; they hatch to release larvae either within a host or into external environment. Adult forms are essentially parasites of human causing soil transmitted helminthiasis, but also affect domesticated mammals. Nematodes have direct life cycles which require no intermediate hosts or vectors. The parasitic infections occur through faecal contamination of soil, food stuffs and water supplies. The main mode of transmission is fecal-oral, where eggs or larvae passed in faeces of one host are ingested by another (Okyay, et al., 2010).

The intensities of helminths infection can be described in terms of eggs per gram (epg) as light (1-100 epg) moderate (101-400 epg) or heavy (≤ 400 epg). Heavy intensities of helminths infections are usually symptomatic and infected individuals suffer multiple morbidity (Alver et al., 2012). Such individuals play an important role in maintaining the life cycle of the parasite since they release large number of eggs with the faeces (Tarko et al., 2013). When the faeces are not properly disposed off, it results to contamination of the environment (Castro et al., 2009).
2.2 General transmission methods of intestinal protozoa and helminths

The main routes of entry of intestinal parasites into the human body are; ingestion, skin penetration, inhalation and autoinfection (Quinnel, 2003). Intestinal helminths infections occur mostly by ingestion of eggs from contaminated soils, for example, in cases of *Ascaris lumbricoides*, *Trichuris trichiura* and occasionally in *Enterobius vermicularis* (Cheesebrough, 2001). Infection by ingestion of infective cysts occurs in protozoa such as *Entamoeba histolytica*, *Balantidium coli* and *Giardia lamblia*. Infection by active skin penetration of the larvae occurs in case of hookworms, *Schistosomes* and *Strongyloides stercoralis* (Greenwood, 2002). Auto-infections occur in cases of *Enterobius vermicularis*, *Taenia solium* and *Hymenolepis nana*, and also *cryptosporidium* (Chiodine et al., 2001).

Adult helminths live in the intestines where they produce thousands of eggs each day (Alver et al., 2012) which contaminate the soil. Infections happen when the eggs attached to fruits or vegetables are ingested if these are not properly cooked, washed or peeled. The eggs may also be ingested in contaminated water or ingested by children who play in contaminated soils and put their hands in mouth (Vam et al., 2009). The transmission of most parasitic infections is faecal-oral (Roberts and Janovy, 2004), resulting from poor sanitation hence contamination of water sources with human faeces. The parasite eggs and cysts have been found to adhere to dust, utensils, finger nails, door handles (Montressor et al., 2001), and currency notes and coins (Lorenzi et al., 2010). Flies and cockroaches may serve as vectors by ingesting the cysts and/or eggs present in faeces and depositing them in food or mechanically carry them on their bodies (Maizels et al., 2014). Studies done in China show that indiscriminate disposal of human faeces and its use in farming contributed greatly to high levels of STH among the population (Wang et al., 2012).
Entamoeba histolytica and Giardia lamblia are the most common intestinal protozoa that are transmitted through drinking contaminated water. Their cysts also contaminate the environment and water supplies (Quinnel, 2003).

2.3 Transmission risks of intestinal protozoa and helminths infections

The risks associated with transmission of intestinal parasites are personal hygiene factors, environmental factors, social economic status and genetic factors. Interactions of these factors influence the infection rate and morbidity associated with intestinal parasitic infections (Ziegebaver et al., 2012).

2.3.1 Personal hygiene factors

It has been reported that in all tropical, subtropical and temperate regions where standards of hygiene are low, infection of intestinal parasites follow ingestion of food and / or water contaminated with intestinal parasites (WHO, 2010). Intestinal parasites eggs or cysts may be carried into the mouth by hands, inanimate objects or consumption of food contaminated by infected food handlers. Ready foods that are sold in open places may be contaminated with helminths eggs and / or protozoa cysts that may be present in the dust (WHO, 2012).

Walking barefoot in moist soils has been associated with high intensity of hookworm infections as a result of skin penetration (Tarko et al., 2013). The filarial form larvae of the hookworms, Strongyloides stercoralis and schistosomes may also penetrate into the human body when people swim in contaminated waters or work in the farms without protective gear (Hotez et al., 2004).
2.3.2 Human behavior and social economic factors

Specific occupations and behavior influence the prevalence and intensity of intestinal parasitic infections. Engagement in agriculture pursuits remains a common denominator for human hookworm infection (Shreshtha et al., 2012). *Ascaris lumbricoides* eggs and hookworm larvae adhere to vegetables hence are readily distributed together with food stuffs sold in markets. A survey in Japan found that *Ascaris lumbricoides* were present in 1780 of 2750 vegetables sold in Tokyo shops (Fukushima et al., 2010). Other studies have established a high prevalence of intestinal parasites among vegetable growers in Turkey (Alver et al., 2012). Infection with intestinal parasites has been found to be endemic among this remote farming community, showing a strong association between low social economic status and the prevalence of intestinal parasitic infections (Mustafa et al., 2001). Sub-factors that significantly correlate with social economic status include; household crowding, literacy, use of protective clothing, defecating practices, food handling practices and source of drinking water. These factors have been identified as being important determinants for prevalence and intensity of infection with intestinal parasites in any locality (Sayasone et al., 2011).

2.3.3 Environmental factors

Studies show that environment of damp alluvial soil shaded by trees provide a perfect environment for development of geohelminths larvae and constitute a significant source of infection and re-infection (Brooker et al., 2008). Moist and warm soils are required to complete the life cycles of hookworms, hence transmission can occur year round in tropical and subtropical countries, while in cooler or drier climates, transmission occurs only in warmer or wet seasons, (Garcia and Bruckener, 2001). The eggs of *Ascaris lumbricoides* develop best in sandy, damp soils and are resistant
to cold and disinfectants (Montessor et al., 2001). Direct sunlight and temperatures above 45°C can kill the eggs (Hotez et al., 2004). Similarly Trichuris trichiura infections are common in areas of high rainfall, high humidity and dense shade.

Ascaris lumbricoides has been found to show higher infection rate in urban environments than rural areas and in contrast higher rate of hookworm infections are typically restricted to rural areas where poverty predominates (Amare et al., 2007). This urban-rural dichotomy can partially be explained in terms of difference in their life cycles. The infective stages of Ascaris lumbricoides are embryonated eggs having enormous capacity of withstanding the environmental extremes of urban environments. Viable Ascaris lumbricoides have been recovered in soil samples more than 10 years after being first deposited (Brooker and Clement, 2009). The social and environmental conditions in slums of developing countries are ideal for persistence of Ascaris lumbricoides and Trichuris trichiura. Many studies have shown high prevalence of these infections in children of slums (Dold and Hollena, 2011).

Climatic factors such as warmth, moist soils and total rainfall affects the transmission of intestinal parasites. Studies on prevalence of helminths infections have shown correlation between amount of rainfall and temperature implying that seasonality affects distribution of intestinal parasites such as hookworm whose transmission rates are higher during rainfall seasons (Ziegbaver et al., 2012). In Saudi Arabia, a seasonal pneumonities resulting from Ascaris lumbricoides larvae migrations have been found to occur annually from March to May (Zaglool et al., 2012).
2.3.4 Genetic factors

Over dispersion is a common feature of population distribution patterns of intestinal parasitic infections in human indicating that certain human populations may have increased genetic susceptibility (Quinnel, 2003). Epidemiological studies suggest that particular populations of individuals could be more predisposed to acquiring heavy hookworm infections despite multiple exposures to parasites and even antihelminthic chemotherapy, indicating genetic influence (Murray et al., 2005). Predisposition has also been described for *Trichurus trichiura* and *Ascaris lumbricoides* infections which may be either immunological, genetic or even a combined immunogenetic basis (Figueired et al., 2010). For instance, some populations with low worm burdens have been noted to be relatively resistant to re-infection since they mount parasite specific IgE and eosinophilic responses (Maizels et al., 2014).

2.4 Co-infection of intestinal parasites

Polyparasitism with either multiple gastro-intestinal helminths and / or protozoa in children is wide spread. Co-infection between helminths and protozoa has synergistic negative impact on health but is not well understood (Brooker et al., 2008). WHO, 2012 postulates that low-intensity of single species infections are associated with little if any measurable morbidity, and this hypothesis has influenced the treatment and control recommendations.

Epidemiological studies have shown, however, that polyparasitism is the norm in helminths-endemic regions. It is likely that individuals in such regions have infections with multiple helminths species at intensities in various combinations including low multiple infections. Cross-sectional surveys conducted in sub-Saharan Africa, South East Asia and South America confirmed that mixed infections are common in
developing countries (Wang et al., 2012). The study found out that poly parasitism increases with age reaching a plateau in adolescent and young adults and decreasing in older age groups (Nissapatorn, 2008). Some research has shown that co-infection with hookworm and Ascaris lumbricoides is associated with high levels of anaemia that would also be expected with single species infections (Brooker et al., 2008).

2.5 Life cycle and transmission of hookworm infections

Adult hookworms inhabit the small intestines of human where they lay eggs containing segmented ova that are passed out in faeces and hatch in moist warm soils into larvae. While Ancylostoma duodenale can be ingested the usual method of infection is through skin penetration of filariform larvae; this is usually caused by walking barefoot or working without protective gear in soils contaminated with fecal matter. Studies done in Mwea Kenya (Kihara et al., 2007) have shown that children who walked bare feet during rainy seasons had increased incidences of hookworm and schistosomiasis infections.

The larvae hatch and penetrate the skin then migrate through the vascular system to the lungs, and from there up to the trachea, and are swallowed. They then pass down the digestive system into the small intestines where they mature into adult worms. They mate inside the host and the female lays up to 240 000 eggs per day and some may lay about 18 to 54 million egg during their life time which pass out in feaces (Figueired et al., 2010).
2.5.1 Pathology of hookworm infections

Symptoms of hookworm infections are related to the intensity, thus light infections are often asymptomatic whereas a mild to heavy infections disrupts the nutritional status of the host (Markell et al., 2008). Ground itch, which is an allergic reaction at the site of larvae penetration, is common in patients infected with *Necator americanus* (Cappello, 2004). Additionally, cough and pneumonities may result as larvae begin to break into the alveoli and travel up the trachea. Once the larvae reach the small intestines, the individual may suffer from diarrhoea and other gastro-intestinal discomfort (Murray et al., 2005).

Heavy intensity of hookworm infection causes major morbidity due to intestinal blood loss, iron deficiency anaemia, and protein malnutrition (Keiser and Utzinger, 2010). The most significant risk of hookworm infection is anaemia, secondary to loss of iron
and protein in the gut. The worms suck blood voraciously and damage the mucosa; however the blood loss in stool is not visibly apparent. The negative impact of high intensity of helminths infections on haemoglobin levels resulting in anaemia has been demonstrated in studies conducted among children in America (Zetterstron, 2004). Other studies have shown that children who suffer from chronic hookworm infection have growth retardation as well as intellectual and cognitive impairments (Boboris et al., 2003). Studies done in Brazil among urban and indigenous children have shown that heavy hookworm infections affect learning capacity and impair physical and mental growth of students (Suma et al., 2003). This in the long run hinders educational achievements and economic development (WHO, 2012).

2.5.2 Diagnosis and treatment of hookworm infections

Diagnosis of hookworm infections is by demonstration of characteristic eggs in faeces by direct microscopy or by concentration methods. The preferred methods of stool preparation are; Kato-Katz and Ridley’s modified formal-ether techniques (Murray et al., 2005). The eggs are oval or elliptical, measuring 60 µm by 40 µm, colourless, not bile stained and with a thin hyaline shell membrane. When released by the worm from the intestines, the eggs contain unsegmented ovum, but as it passes down the intestines, the ovum develops and thus the eggs passed out in faeces have segmented ovum, usually with 4 to 8 blastomeres (Escobedo et al., 2009).

If the stool specimen is stored at room temperature for more than 24 hours or under tropical conditions, they continue to develop and larvae may hatch out, so eggs might no longer be evident (Cheesebrough, 2001). Adult worms may also be detected in stool samples while aspiration of duodenal contents may reveal both eggs and adult worms (Standley, 2010).
The recommended treatments are albendazole and mebendazole, which are effective both in intestinal stage and during the stage the larvae is still migrating under the skin. (WHO, 2014). WHO 2012 also recommends antihelminthic treatment in pregnant women after first trimester while for patients who suffer from anaemia ferrous sulfate should be administered. Other important issues related to the treatment of hookworm are reinfection and drug resistance. It has been shown that reinfection after treatment can be extremely high. Some studies even show that 80% of pretreatment hookworm infection rates can be seen in treated communities within 30–36 months (Gambao et al., 2000). While reinfection may occur, it is still recommended that regular treatments be conducted as it will minimize the occurrence of chronic outcomes. Generally human nematodes are less likely to develop resistance due to longer reproducing times, less frequent treatment, and more targeted treatment (Keiser and Utzinger, 2010).

2.6 Life cycle and transmission of *Trichuris trichiura*

*Trichuris trichiura* eggs passed in faeces embryonate in damp soils and become infective to human if ingested. The eggs shells are dissolved by digestive juices in the small intestines and hatch into larvae in the small intestines; the larvae moves into caecum and large intestines where they penetrate the mucosa and mature into adults. The life cycle from time of ingestion of eggs to development of mature worms takes approximately three months. During this time, there may be absence of eggs in stool samples due to lack of egg production and shedding. The female begin to lay eggs after three months of maturity, may live up to five years, during which it produces about 20 000 eggs per day (Suma et al., 2003).
2.6.1 Pathology of *Trichuris trichiura* infection

Heavy infection with *Trichuris trichiura* cause inflammation of mucosa and occasional ulceration of large intestines resulting to blood stained stool. The surface tissues of rectum become extremely oedematous leading to rectal prolapses (Roberts and Janovy, 2009). Colonic obstructions due to tangled worms and perforations have been reported. Prolonged massive infections lead to iron deficiency anaemia due to general malnutrition and blood loss from friable colon (Strunz *et al.*, 2013).
2.6.2 Diagnosis and treatment of *Trichuris trichiura* infections

*Trichuris trichiura* infections are usually diagnosed by microscopic examination of stool samples to detect the characteristic brown barrel shaped eggs that have bipolar protuberances (Ryan and Ray, 2004). Typically, the Kato-Katz thick smear technique is used for identification of the eggs in stool specimen (Keiser *et al*., 2010). Adult worms may also be seen in prolapsed rectal mucosa (WHO, 2010).

The current drugs of treatment for adult worms are mebendazole and albendazole however, in cases of iron deficiency; comprehensive treatment should be undertaken (Strunz *et al*., 2013). Preventive chemotherapy should be done after every three months to prevent reinfection (Hotez, 2009).

2.7 Life cycle and transmission of *Ascaris lumbricoides*

*Ascaris lumbricoides* adult worms reside in small intestines where they pass out eggs containing unsegmented ova together with faeces. The female can lay up to 240 000 eggs per day for a year (Dold and Hollena, 2011). The fertilized eggs require moist soils and warm temperatures to embryonate and become infective if ingested. These eggs can persist in the soil for up to 10 years or more because of a lipid layer that makes them resistant (Murray *et al*., 2005). Once ingested, the eggs hatch in the small intestines into larvae that penetrate the walls of duodenum and get into the circulation and migrate into the lungs. They are coughed and swallowed into the small intestines where they mature into adults.

2.7.1 Pathology of *Ascaris lumbricoides* infections

*Ascaris lumbricoides* infections are usually asymptomatic, clinical disease is largely restricted to individuals with heavy infections (Zetterstron, 2004). Symptoms are
related to either to larvae migrating stage or adult worms in the large intestines. Heavy infections lead to intestinal obstruction especially at ileocal valve causing colicky abdominal pain, vomiting and constipation (Pinar et al., 2004). Migrating larvae may cause inflammation and hypersensitive reactions in the lungs leading to formation of granuloma and eosinophils infiltration. This condition in the lungs can lead to Loeffler’s Pneumonia in which pools of blood and dead epithelial cells clog air spaces in the lungs (Keiser et al., 2010).

2.7.2 Diagnosis and treatment of Ascaris lumbricoides infections

Eggs may be detected in stool samples by microscopy or concentration by formalin ether technique. During pulmonary phase, the larvae may be found in fluid aspirated from lungs or detected in sputum (Dold and Hollena, 2011). Sero-diagnosis techniques such as IHA and IFAT are useful in diagnosis of extraintestinal ascariosis (Greenwood, 2002).

The treatment recommended by WHO are albendazole, mebendazole, levamisole or pyrantelpamoate (WHO, 2013). Corticosteroids can be used to treat some symptoms such as inflammation (Hotez, 2009). In some cases with severe infestation, the sudden death of the worms may cause bowel obstruction requiring surgical interventions (Harhay et al., 2010). Reinfection may occur rapidly after treatment hence there is need for frequent antihelmintic drug administration to maximize the benefits of preventive chemotherapy (Hotez, 2009).
Figure 2.3 Life Cycle of *Ascaris lumbricoides* (CDC, 2010)

2.8 Life cycle and transmission of *Entamoeba histolytica*

*Entamoeba histolytica* developmental stages generally consists of feeding trophozoites or cysts stages both of which may be present in stool of infected person. The trophozoites stage exists in host’s tissues, body fluids and loose stool. While trophozoites are ideally suited for their parasitic mode of existence, they do not survive long outside the host and if ingested they are easily destroyed by gastric acid in the host’s stomach. Cysts are usually found in formed stool and survive outside the host in water, soil and or food especially on moist conditions. Human get infected by ingestion of cysts in fecally contaminated water, food or hands but they may also be transmitted through anal-oral sex (Ryan and Ray, 2004). The excystment occurs in the
stomach and trophozoites move to the small intestines then to large intestines where they live and multiply and pass out cysts or trophozoites in faeces.

Figure 2.4 Life Cycle of *Entamoeba histolytica* (CDC, 2010).

2.8.1 Pathology of *Entamoeba histolytica* infections

Amoebiasis can be asymptomatic, or may lead to amoebic dysentery or liver abscesses. In acute amoebiasis, there is severe dysentery with bloody diarrhoea, mucus and necrotic mucosa accompanied by acute abdominal pain tenderness and fever. The amoeba trophozoites can bore into intestines causing lesions. The intestinal
lesions are flask-like primary ulcers to large necrotic areas and are confined to large intestines, frequently cecal and sigmoidorectol regions. In extraintestinal amoebiasis, the liver is chiefly invaded, resulting in amoebic hepatitis or liver abscesses which can be fatal if untreated. This is characterized by enlarged tender liver with pain in hyochondrum. Less frequently abscesses may be seen in lung, spleen, brain, kidney, skin and gonads leading to severe pathological conditions (Stanley, 2003).

2.8.2 Diagnosis and treatment of Entamoeba histolytica

The protozoan infections are diagnosed by showing the presence of trophozoites in loose stool and cysts in formed stool or colonic scrapings from ulcerated areas in cases of amoebiasis (Haque et al., 2003). Diagnosis of amoebiasis by microscopic identification of the cysts and protozoa in stool samples is insensitive and unable to distinguish invasive Entamoeba histolytica which causes intestinal and extra-intestinal amoebiasis from the commensal Entamoeba dispar (Heckendorn et al., 2002). The alternative to microscopy diagnosis is ELISA which identifies Entamoeba histolytica antigens in stools or antibody in serum. Serological techniques that have been used for immunodiagnosis of amoebiasis are complement fixation, IFAT and latex agglutination (Stanley, 2003). Studies in America have shown that immunological diagnosis of amoebiasis was 98% effective as compared to other methods (Bogochi et al., 2006).

Prevention of amoebiasis requires interruption of the fecal-oral spread of the infectious cyst stage of the parasite (Lorenzi et al., 2010). Since the cysts are resistant to low doses of chlorine or iodine. In developing countries water must be boiled before it is safe to drink and raw vegetables must be washed with soap and then soaked in vinegar for 15 minutes before they can be eaten (WHO, 2012). Since
amoebiasis often spreads through households, it is important to screen family members for intestinal amoebiasis infections (WHO, 2010).

Intestinal infections are usually treated with nitromidazole derivatives as they are effective against trophozoites stage. Since these medications have no effects on cysts, the treatment is followed by agents such as paromomycin or diloxanidefuroate. Liver abscesses are treated with drugs like metronidazole and chloroquine (WHO, 2010).

2.9 Life cycle and transmission of *Giardia lamblia*

Mature cysts are the infective form of *Giardia lamblia* and infection is initiated when cysts are ingested in contaminated water or food or through direct fecal oral contact which may occur during oral sex (Caler and Lorenzi, 2010). The cysts are highly resistant to environmental conditions, being able to survive in cold mountain streams; stomach acids, chlorine and even UV treated water (Cassio *et al*., 2003). It is consequently the cause of many infections occurring in recreational facilities (Castro *et al*., 2009).

Once the cysts are ingested excystation occurs in the duodenum releasing numerous trophozoites which are in active stage of feeding and motility (Tanyuskei and Petri, 2003). The trophozoites undergoes asexual replication through longitudinal binary fission, the resulting trophozoites form cysts which then pass through the digestive system in the faeces. While the trophozoites may be found in the faeces, only the cysts are capable of surviving outside of the host (Harhay *et al*., 2010).

The cyst can survive for weeks to months in cold water hence can be present in contaminated wells and water systems, especially stagnant water sources, such as naturally occurring pools, water storage systems, and even clean-looking mountain streams. They may also occur in city reservoirs and persist after water treatment, as
the cysts are resistant to conventional water treatment methods, such as chlorination (Heckendorn et al., 2002). *Giardia lamblia* is a potential zoonotic with threats from livestock and other domesticated animals especially in settings where animals are closely integrated in the community (Cassio et al., 2003).

![Figure 2.5 Life Cycle of *Giardia lamblia* (CDC, 2010).](image)
2.9.1 Pathology of *Giardia lamblia* infections

*Giardia lamblia* does not penetrate the intestinal wall but feed on mucous secretions. The trophozoites attach themselves with the help of the sucking discs onto the surface of the epithelial cells in the duodenum hence may cause inflammation. Large number of trophozoites may lead to malabsorption especially of fat soluble substances such as vitamin B\textsubscript{12} (Caler and Lorenzi, 2010). Patients may complain of dull epigastric pain, flatulence and chronic diarrhoea of steatorrhoea type (Chiodine *et al*., 2001).

2.9.2 Diagnosis and treatment of *Giardia lamblia*

*Giardia lamblia* infections can be diagnosed by microscopic identification of cysts in formed stool and trophozoites in diarrhoeal stool using normal saline and iodine preparation. Multiple stool examinations are recommended, since the cysts and trophozoites are not shed consistently (Tanyuskei and Petri, 2003). Trophozoites of *Giardia lamblia* may be detected in the bile aspirated from duodenum by incubation and by enterotest (Garcia and Bruckener, 2001). For detection of *Giardia lamblia* in faeces specimens, a fluorescent method using monoclonal antibodies is extremely sensitive and specific (Escobedo *et al*., 2009). Anti-giardia antibodies, in patient serum, may be detected by ELISA and IFAT (WHO, 2013).

Treatment of giardiasis is carried out with metronidazole and furazolidone. Metronidazole is very effective but has potential carcinogenicity in rats (Hotez *et al*., 2014). Tinidazole has proven more effective than metronidazole as a single dose (WHO, 2012).
2.10 General method of prevention and control of intestinal parasitic infections

Prevention and control of intestinal parasitic infections is aimed at reducing morbidity and re-infection among populations. Intervention measures are also aimed at reducing environmental contamination with parasites eggs and cysts and interrupting their life cycles.

2.10.1 Environmental sanitation and hygiene

Proper disposal of human and animal waste prevents contamination of food and drinking water sources, especially intestinal parasitic infections that are transmitted by fecal-oral route (Asaolu and Ofoezie, 2003). Control of flies and other vectors in food selling points prevents dispersal of infective stages of intestinal parasites in food (Markel et al., 2008). Studies indicate that washing hands, raw vegetables, fruits and utensils prevent cross contamination of food with eggs and cysts of intestinal parasites.

Adequate cooking of food destroys all stages of intestinal parasites; however microwave cooking does not reliably kill all parasites in food stuff because heating is uneven and may permit survival of some parasites (Hotez, 2009). Foods sold in markets may be contaminated by hands that have not been washed after defecation or from flies that land on both food and faeces hence increased risks of transmission of intestinal parasites to consumers (Nyarongo et al., 2008).

2.10.2 Health education

Intestinal parasitic infections can be prevented or greatly reduced through cost effective interventions such as avoiding ingestion of contaminated food stuff. Food safety measure help prevent intestinal parasitic infections which are transmitted through food and water. Proper food handling techniques should be applied and
asymptomatic carriers should be removed from food handling occupations and treated (Vigor et al., 2002). Health education involves the following; drug treatment for those already infected, because they can act as reservoir for intestinal parasites, sanitary and personal hygiene improvement to avoid re-infection and break their life cycles preventing person to person transmission, hygienic food handling techniques and hand washing (WHO, 2010). Proper personal hygiene, for example, washing of hands with soap after visiting toilets and before handling food should be practiced. A study done in Nigeria showed that washing hands greatly reduced infection with STH among urban residents (Strunz et al., 2013). People should be educated on proper sanitation, which involves promotion of use of latrines hence discouraging the use of human excreta as fertilizer in agriculture (Wang et al., 2012). Such latrines should include the pour flush and septic tanks, which are superior from hygienic point of view to traditional latrines (Ziegebaver et al., 2012). Toilets should be kept clean and flies should be controlled (De Silvia et al., 2003), to prevent them from mechanically carrying cysts and eggs to food.

Health education should be multidisciplinary where various stakeholders will be involved to educate the public on sanitation and personal hygiene in controlling intestinal parasitic infection.

2.10.3 Treatment of water

Safe drinking water is a proven intervention measure that consistently reduce diarrheal disease incidence among users in developing countries in the world (Stanley et al., 2003). Chlorination and / or filtration of drinking water have been hailed as a major method of ensuring safe drinking water. However some cysts and oocytes are resistant to chlorination (WHO, 2013).
2.10.4 Chemotherapy

The popular approach to control of intestinal parasitic infections is through school deworming programs. According to WHO, institutions have a number of advantages as they allow policy makers to use the existing infrastructure and institutions for dispensation of medical treatment. Furthermore students already plan to attend school on regular basis hence health education can be incorporated (WHO, 2010). A much larger and rapidly growing children population in developing countries remains untreated and suffering from more than one parasitic infection (WHO, 2011). In 2012, 285 million children in need of treatment received anthelminthic drugs corresponding to a global coverage of 32.6% (WHO, 2013).

In developing countries, groups at higher risk of STH are often treated without prior diagnosis; these groups identified by WHO are pre-school and school age children, women of child bearing age and adults in occupation such as medical laboratory technicians, where there is high risk of infection (WHO, 2013).

WHO strategy for reduction of intestinal parasitic infections is by control of morbidity through periodic treatment of the people at risk such as pre-school and school-age children living in endemic areas. For such groups they recommend deworming without previous diagnosis (WHO, 2011). Treatment should be given once every three months (WHO, 2010). Periodic deworming can be integrated with school health programs as they allow easy provision of health and hygiene educational components such as hand washing and provision of proper sanitation. Integration of STH control programs in the school system has been effective in Nigeria (Sayasone et al., 2011). Studies have shown that deworming in schools reduce the burden of disease in
neighboring untreated schools, in addition it has benefits of reducing adult infection rates since children are significant source of transmission (Odiere and Opisa, 2011).

The recommended medicines albendazole 400mg and mebendazole 500mg are effective, inexpensive and easy to administer by non-medical personnel such as teachers (Hotez, 2009). These medications are donated to the national Ministries of Health through WHO with the global target of eliminating morbidity due to STH by 2020 (WHO, 2011).

2.10.5 Integrated methods

Studies have demonstrated that combined treatment to eliminate the helminths, improved sanitation aimed at reducing environmental contamination and health education to control the spread and transmission of intestinal parasites, are more efficient in elimination of intestinal parasites among populations (Asaolu et al., 2003), than any single method.
CHAPTER THREE

MATERIALS AND METHODS

3.1 Study area

The study was carried out in four secondary schools within Maara Sub-County of Tharaka-Nithi County, which is located between longitude 37$^0$ 18’ 37” and 37$^0$ 28’ 33” East and between latitude 00$^0$ 07’ 23” and 00$^0$ 26’ 19” South at an approximate altitude of 5200 m – 6500 m above sea level. It covers an area of 2,638.8 Km$^2$ with a population of 365,330 people resulting to a population density is 138 per Km$^2$ of which 65% live below poverty line (CBS, 2001). The area is on the southeastern slopes of Mt. Kenya hence is transversed by a large number of rivers and streams which constitute the major source of water supply to the community in the region. However, a large number of the population utilizes unprotected dugout wells which could be a source of contamination. Some areas are supplied with piped water, most of which is not treated. The main economic activity is small scale farming hence there is frequent contact with the soil. Most of the households have pit latrines but maintenance of proper sanitation and hygiene is poor. Records from the Tharaka-Nithi County hospital cited helminthiasis as one of the three most common diseases together with malaria and typhoid.

3.2 Study design

This was across sectional descriptive study involving secondary school students in Maara Sub-County, Tharaka-Nithi County.
3.3 Study population

The study involved Form One, Two and Three students aged between 14-19 years from four randomly selected public secondary schools within Maara Sub-County. These schools were; Muthambi Girls, Kajiunduthi, Kyeni and Munga secondary schools. Muthambi is a girls’ boarding school; Kajiunduthi is a boys’ boarding while Kyeni and Munga are mixed day schools.

3.3.1 Inclusion criteria

The inclusion criteria were form one, two and three students aged between 14 to 19 years in the selected secondary schools. The students were neither on antihelminthic nor anti/protozoan medication or had not taken the medication in the previous two months prior to the study, and signed the written consent.

3.3.2 Exclusion criteria

The exclusion criteria was all form four students, those aged below 14 years and above 19 years. Students on antihelminthic and/or anti/protozoan medication or had taken in the past two months prior to the study. Excluded also were all students who had not signed the written consent.

3.4 Sample size determination

The sample size was determined by the method used by Sapoka et al., (2006), for calculating the sample size where the population is less than 10 000. The approximate population of form one, two and three students in each of the selected secondary schools was as follows; Muthambi girls and Kajiunduthi 600 each, while Munga and Kyeni 300 each, giving a total of 1,800 targeted students in the four schools.

Using the method of Sapoka et al., (2006) to derive the sample size;
n = \frac{Z^2 P (1-P)}{\hat{e}^2}

n = the desired sample size for a population less than 10 000

Z = the standard deviation=1.96, which corresponds to 95% confidence level.

P = the proportion of the target population estimated to have a characteristic =0.5
(since the target population with the characteristic under investigation is not known, 50% is used).

\hat{e} = is the level of precision taken as a percentage usually at 5%.

n = \frac{Z^2 P (1-P)}{\hat{e}^2}

n = 1.96^2 * 0.5(1-0.5) / 0.5^2

n = 3.8416 * 0.5 * 0.5 / 0.0025

n = 384.16.

A total of 422 students were targeted to be sampled to give allowance of 10% dropout in the course of the study (Kirby et al., 2002).

3.5 Sampling technique

This was a cross-sectional descriptive study involving secondary school students in Maara Sub-county, Tharaka-Nithi County. A multistage sampling technique was used where four divisions namely; Muthambi, Mwimbi, Ganga and Gitije divisions were randomly selected from a total of eight divisions in Maara Sub-County (Appendix I). The public secondary schools in each division were categorized into; Boys’ boarding, girls’ boarding and mixed day schools. One public secondary school was randomly selected from each category, out of an average of 9 schools per division. The sample size of 422 students was distributed according to the number of students in each
school in the ratio of 1 day:2 boarding schools. Munga and Kyeni day secondary schools had approximately 300 students in form one, two and three, hence 71 students were sampled in each of the two school, while Muthambi and Kajiunduthi boarding schools had about 600 students each, hence 140 students were sampled per school. The number of students sampled in each school was then proportionately distributed among each of the three classes. In the day schools, 23 (71/3) students were selected while in the boarding secondary schools, 47 (140/3) students were selected from an average of 45 students per class. The selection was done from students present in class using the class register by allocating random numbers.

3.6 Data collection

Data on the occurrence of intestinal parasitic infections among students was obtained by laboratory investigations of the collected stool specimen. Data on personal hygiene, social demographic and environmental factors was collected using predesigned questionnaires. The questionnaires were filled by students one day before collection of stool specimen after which they were given specimen sterile specimen bottles to bring stool specimen the following morning. A check list on the environmental sanitation in the four schools was filled by boarding masters, who were teachers in the respective schools. The stool specimens were collected as described below.

3.6.1 Collection of stool specimen and laboratory procedures

A total of 422 stool specimens were collected from both male and female students from Form 1, 2 and 3 from four secondary schools in Maara Sub-County. The students were given sterile, capped specimen bottles labeled with random numbers, and an applicator stick. They were instructed to collect a first morning stool specimen.
Stool specimen for each of the classes were collected on three consecutive days per week beginning with the Form ones, followed by Form Twos and lastly Form Threes for each of the schools. The stool specimens from all the four secondary schools were analysed within a period of one month. The specimens were taken to Mwangarimwe Bethsaida Hospital laboratory for analysis within two hours of collection. The laboratory investigations were carried out by the researcher assisted by two qualified laboratory technicians. Randomly picked stool specimen were re-examined by a third technician to increase the accuracy of results.

3.6.2 Gross examination of stool specimens

Gross examination of the stool was done for consistency, colour, presence of blood, mucus and adult worms or segments. The specimens were then processed for direct wet mounts and concentration techniques before being observed under a microscope.

3.6.2 Direct wet mounts

Direct wet mounts were prepared to observe the presence or absence of adult worms, worm segments, eggs, and protozoa cysts and / or trophozoites according to laboratory practice (Cheesebrough, 2001). This was done by picking approximately 2g of stool specimen with an applicator stick and mixing it with a drop of normal saline placed in the centre of the left half of a microscope slide and a drop of 0.9 % Lugol’s iodine solution placed in the centre of the right half of the same slide. The preparations were covered with cover slips and a drop of eosin added under the cover slip to aid in identification of motile protozoan trophozoites (Utzinger et al., 2010). The slides were examined at X10, X40 and X100 objective lenses.

The criteria for identification of protozoa trophozoites was motility structures, type of motility, and number of nuclei, karysome and chromatid bars (Heckendorn et al.,
2002). Other structures such as cytoplasmic inclusions like erythrocytes and yeast were used in identifying amoebic trophozoites while structural details such as sucking disks and spiral groove or filaments were used in identification of flagellate trophozoites (Markell et al., 2008). Presence or absence of adult worms, eggs, larvae, protozoan trophozoites or cysts was recorded for each specimen.

### 3.6.4 Concentration technique

The modified Ridley’s formal-ether stool concentration method was used to prepare concentrated stool specimen to determine the intensity of helminths infection according to Garcia and Bruckener (2001). Using a dropper, 4ml of formal saline was placed in a screw capped test tube and an applicator stick used to transfer 2g of faecal specimen into the test tube. The test tube was then shaken vigorously to emulsify the content which was sieved through four layers of surgical gauze into a centrifuge tube. Using a dropper, 3 ml of ether was added into the test tube, capped and centrifuged at 2000 rpm for 2 minutes. The thick plug was loosed with an applicator stick and the supernatant discarded leaving the sediments. The sediments ware picked using a pasteur pipette and used to prepare the slides for microscopic observations. The preparations were covered with cover slips and examined first at X10 and X40 objectives. The helminths eggs on entire preparation were identified, counted, the total divided by 2 to get the epg of stool specimen and recorded.

### 3.6.5 Questionnaires

A total of 422 copies of predesigned questionnaires (appendix IV) were used to collect data on social demographic factors, personal hygienic practices and transmission risks of intestinal parasitic infections both in school and home environments. The questionnaires contained three sections; the first section was on
social demographic factors such as age, class, residence, the second section was on environmental factors including water source, type of toilets, presence of flies in toilet and / or latrines, and the last section was on hygiene practices such as washing hands, fruits and other food items. Some samples of the questionnaires were pretested on two students randomly selected from each of the four schools. A check list was given to the boarding masters in each of the four schools to collect data on environmental sanitation within the school.

3.7 Data analysis

The quantitative data was coded and double entered into a computer data base designed using MS-Access application. Data cleaning and validation was performed in order to achieve a clean dataset that was exported into SPSS 20. The rates of intestinal parasitic infections among the different schools, sexes, age and school type was analysed by expressing the positive samples as a percentage of the total number of students sampled. The data was compared using chi squared test ($\chi^2$) and ANOVA to predict whether there was significant association. The intensity of helminths infection was expressed as epg and described as light infection (1-100), moderate (101-400) and heavy infection ($\geq$400) (Keiser and Utzinger, 2010). Adjusted odds ratio (aOR) was used to determine the association of environmental and personal hygiene practices and intestinal parasitic infections. The difference was considered significant at a p-value $\leq$ 0.05. Quantitative data was presented using tables and graphs.
3.8 Ethical clearance and considerations

The study was approved by the graduate school, Kenyatta University. Ethical clearance was obtained from The Ethical Committee of Mwangarimwe Bethsaida Hospital where the stool specimen were analysed (Appendix VI). Students’ participation in the study was fully voluntary and confidentiality was maintained during the study. A written informed consent was signed by students above 18 years while for those below 18 years parents or guardians signed their consent (Appendix IV and V). The students below 18 years in day schools were given the written consent to have them signed at home while those in boarding schools had theirs signed during the school holiday. The procedure was non-invasive hence not harmful to the subjects. Those who tested positive for the parasites were referred to the nearest health centers for treatment.
CHAPTER FOUR
RESULTS

4.1 Occurrence of protozoa and helminths infections among students.

Out of the total 422 students recruited at the start of the study, only 384 among them provided stool specimen for three consecutive days. They also completed all the information required on the questionnaires. Of these students, 47.4% and 52.6% were males and females respectively. The intestinal parasitic infection rate for both helminths and protozoa was 36.2%. The infections due to protozoa were 19.0%, 17.2% were due to helminths, while multiple infections were 3.6%.

The types of intestinal parasitic infections found in the sampled students were protozoa; *Entamoeba histolytica*, *Giardia lamblia* and helminths *Ascaris lumbricoides*, *Trichuris trichiura* and hookworms. Among the protozoan infections *Entamoeba histolytica* had the highest infection rate (16.9%). *Ascaris lumbricoides* had the highest infection rate (10.4%) among the helminths a shown in Figure 4.1.
Figure 4.1 Protozoa and helminths among students from the four schools

The infection rate of protozoa and helminths per school is shown on Table 4.1. Kyeni Day school had the highest rate 42.2% while Kajiunduthi boy’s boarding school had the least at 32.8%. There was significant difference in the infection rates between the two schools (F=94.23, p=0.01, df=1).
Table 4.1 Infection rates (%) of helminths and protozoa among the four schools

<table>
<thead>
<tr>
<th>School</th>
<th>Number of students tested</th>
<th>Number of students infected</th>
<th>Infection rate (%)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kyeni (mixed day)</td>
<td>64</td>
<td>27</td>
<td>42.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Munga (mixed day)</td>
<td>64</td>
<td>25</td>
<td>39.1</td>
<td></td>
</tr>
<tr>
<td>Muthambi (girl’s boarding)</td>
<td>128</td>
<td>45</td>
<td>35.2</td>
<td></td>
</tr>
<tr>
<td>Kajiunduthi (boy’s boarding)</td>
<td>128</td>
<td>42</td>
<td>32.8&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Total infections</td>
<td>384</td>
<td>139</td>
<td>36.2</td>
<td>F=94.23, p=0.01, df=1</td>
</tr>
</tbody>
</table>

Infection rate = Number of students infected / number of students tested per school.

<sup>a, b</sup> shows results that were statistically significant

Infection rate in different schools was statistically significant (F=94.23, p=0.01, df=1).

The most common protozoa in all the schools was *Entamoeba histolytica* at (16.9%), however there was no significant difference in the infection rates due to protozoa infections among the different schools ($\chi^2=17.3$, p=0.053, df=1) (Table 4.2).

*Ascaris lumbricoides* infections were the most common among the helminths in all the schools sampled at 10.4% while *Trichuris trichiura* was the least at 2.9%. Munga Day school had the highest infection due to helminths at 18.8% while Kajiunduthi boy’s boarding secondary had the least at 16.4%, The difference in the infection rate was statistically significant ($\chi^2=200$, p=0.01, df=1).

Over all, the day secondary schools had a higher proportion of students infected with intestinal parasites at 40.6% compared to 34% in boarding secondary schools, the difference in the infection rate was statistically significant ($\chi^2=249.0$, p=0.00, df=2).
Table 4.2 Infection rates (%) of various species intestinal parasites per school

<table>
<thead>
<tr>
<th>Parasites</th>
<th>Schools</th>
<th></th>
<th>Day school</th>
<th></th>
<th>Boarding</th>
<th></th>
<th>Total infections</th>
<th></th>
<th>ANOVA p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S^1 n=64</td>
<td></td>
<td>S^2 n=64</td>
<td></td>
<td>S^3 n=128</td>
<td></td>
<td>S^4 n=128</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. histolytica</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14(21.9%)</td>
<td></td>
<td>12(18.6%)</td>
<td></td>
<td>20(15.6%)</td>
<td></td>
<td>19(14.8%)</td>
<td></td>
<td>65(16.9%)</td>
</tr>
<tr>
<td>G. lamblia</td>
<td>2(3.1%)</td>
<td></td>
<td>1(1.6%)</td>
<td></td>
<td>3(2.3%)</td>
<td></td>
<td>2(1.6%)</td>
<td></td>
<td>8(2.8%)</td>
</tr>
<tr>
<td>Total protozoa</td>
<td>16 (25.0%)</td>
<td></td>
<td>13 (20.3%)</td>
<td></td>
<td>23 (18.0%)</td>
<td></td>
<td>21 (16.4%)</td>
<td></td>
<td>73 (19.0%)</td>
</tr>
<tr>
<td>A. lumbricoides</td>
<td>6 (9.4%)</td>
<td></td>
<td>7 (10.9%)</td>
<td></td>
<td>14 (10.9%)</td>
<td></td>
<td>13 (10.2%)</td>
<td></td>
<td>40 (10.4%)</td>
</tr>
<tr>
<td>Hookworms</td>
<td>3 (4.7%)</td>
<td></td>
<td>4 (6.3%)^a</td>
<td></td>
<td>5 (3.9%)</td>
<td></td>
<td>3 (2.3%)</td>
<td></td>
<td>15 (3.9%)</td>
</tr>
<tr>
<td>T. trichiura</td>
<td>2 (3.1%)</td>
<td></td>
<td>1 (1.6%)</td>
<td></td>
<td>3 (2.3%)</td>
<td></td>
<td>5 (3.9%)</td>
<td></td>
<td>11 (2.9%)</td>
</tr>
<tr>
<td>Total helminths</td>
<td>11 (17.2%)</td>
<td></td>
<td>12 (18.8%)</td>
<td>^b</td>
<td>22 (17.2%)</td>
<td></td>
<td>21 (16.4%)</td>
<td></td>
<td>66 (17.2%)</td>
</tr>
<tr>
<td>Total parasites</td>
<td>27 (42.2%)</td>
<td></td>
<td>25 (39.1%)</td>
<td></td>
<td>45 (35.2%)</td>
<td></td>
<td>42 (32.8%)</td>
<td></td>
<td>139 (36.2%)</td>
</tr>
<tr>
<td>Totals</td>
<td>52 (40.6%)^c</td>
<td></td>
<td>87 (34.0%)</td>
<td></td>
<td>139 (36.2%)</td>
<td></td>
<td></td>
<td></td>
<td>P=0.00</td>
</tr>
</tbody>
</table>

n = total number of students tested per school
Percentage infections = Number of infected students / n
S^1 - Kyeni  S^2 - Munga  S^3 - Muthambi  S^4 - Kajiunduthi
Total infections in day schools = Infections in S^1 + infections in S^2
Total infections in boarding schools = Infections in S^3 + infections in S^4
a, b and c shows results that were statistically significant.

Comparing infection rates by intestinal protozoa and helminths among different classes, it was shown that infection rates were highest among Form Three students (38.1%) followed by Form two students (37.5%) while Form one students had the least at (33.1%) in all the four schools combined (Table 4.3). There was no significant difference in the overall infection rates among the different classes (F=144.82, p=0.059, df=2).
The infection rate among Form one students was highest in Munga secondary (59.1%) and lowest in Muthambi (23.3%) the difference was statistically significant ($\chi^2=292.0$, $p=0.018$, df=1).

**Table 4.3 Infection rates (%) of helminths and protozoa among different classes**

<table>
<thead>
<tr>
<th>School</th>
<th>Class</th>
<th>$S^1$ n=64</th>
<th>$S^2$ n=64</th>
<th>$S^3$ n=128</th>
<th>$S^4$ n=128</th>
<th>Total infections</th>
<th>ANOVA p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Form one</td>
<td>n=130</td>
<td>8(38.1%)</td>
<td>13(59.1%)</td>
<td>10(23.3%)</td>
<td>12(28.6%)</td>
<td>43(33.1%)</td>
<td>P=0.018</td>
</tr>
<tr>
<td>Form Two</td>
<td>n=128</td>
<td>12(57.1%)</td>
<td>6(27.3%)</td>
<td>17(39.5%)</td>
<td>13(31.0%)</td>
<td>48(37.5%)</td>
<td>P=0.676</td>
</tr>
<tr>
<td>Form Three</td>
<td>n=126</td>
<td>7(33.3%)</td>
<td>6(27.3%)</td>
<td>18(41.9%)</td>
<td>17(40.5%)</td>
<td>48(38.1%)</td>
<td>P=0.820</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>27(42.2%)</td>
<td>25(39.1%)</td>
<td>45(35.2%)</td>
<td>42(32.8%)</td>
<td>139(36.2%)</td>
<td>P=0.10</td>
</tr>
</tbody>
</table>

$S^1$ - Kyeni  $S^2$-Munga  $S^3$-Muthambi  $S^4$-Kajiunduthi  

- show results with statistically significant difference.

$n= $ total number of students.

Infection rate between various age groups was not statistically significant ($F=144.82$, $p=0.059$, df=2)

The Form three students had slightly higher infection rate (20.6%) with protozoa than the other two classes (Table 4.4). For helminths, Form two students had slightly higher infection rate (21.1%) while the Form ones had the least (13.1%). There was no significant difference in the infection rate due to various helminths and protozoa species among the classes ($\chi^2=16.8$, $p=0.079$, df=10).
Table 4.4 Infection rates (%) with different species of helminths and protozoa according to classes.

<table>
<thead>
<tr>
<th>Parasites</th>
<th>Form one n=130</th>
<th>Form two n=128</th>
<th>Form three n=126</th>
<th>Total infections</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>E. histolytica</em></td>
<td>24 (18.5%)</td>
<td>19 (14.8%)</td>
<td>22 (17.5%)</td>
<td>65 (16.9%)</td>
</tr>
<tr>
<td><em>G. lamblia</em></td>
<td>2 (1.5%)</td>
<td>2 (1.6%)</td>
<td>4 (3.2%)</td>
<td>8 (2.8%)</td>
</tr>
<tr>
<td><strong>Total protozoa</strong></td>
<td><strong>26 (20.0%)</strong></td>
<td><strong>21 (16.4%)</strong></td>
<td><strong>26 (20.6%)</strong></td>
<td><strong>73 (19.0%)</strong></td>
</tr>
<tr>
<td><em>A. lumbricoides</em></td>
<td>8 (6.2%)</td>
<td>16 (12.5%)</td>
<td>16 (12.7%)</td>
<td>40 (10.4%)</td>
</tr>
<tr>
<td>Hookworms</td>
<td>5 (3.8%)</td>
<td>6 (4.7%)</td>
<td>4 (3.1%)</td>
<td>15 (3.9%)</td>
</tr>
<tr>
<td><em>T. trichiura</em></td>
<td>4 (3.1%)</td>
<td>5 (3.9%)</td>
<td>2 (1.6%)</td>
<td>11 (2.9%)</td>
</tr>
<tr>
<td><strong>Total helminths</strong></td>
<td><strong>17 (13.1%)</strong></td>
<td><strong>27 (21.1%)</strong></td>
<td><strong>22 (17.2%)</strong></td>
<td><strong>66 (17.2%)</strong></td>
</tr>
<tr>
<td><strong>Total infections</strong></td>
<td><strong>43 (33.1%)</strong></td>
<td><strong>48 (37.5%)</strong></td>
<td><strong>48 (38.1%)</strong></td>
<td><strong>139 (36.2%)</strong></td>
</tr>
</tbody>
</table>

Students of all age sets were predisposed to infections by various protozoa and helminths species ($\chi^2=16.8$, $p=0.079$, df=10).

The male students had an overall infection rate of 39.6%, which was slightly higher compared to females at 33.2%, the difference was not statistically significant ($\chi^2=3.92$, $p=0.56$, df=5) (Table 4.5). Infection rate with both protozoa and helminths were slightly higher in males than in females at 20.9% and 17.3% respectively for protozoa, and 18.7% and 15.8% respectively for helminths.
Table 4.5 Helminths and protozoa infections in male and female students.

<table>
<thead>
<tr>
<th>Intestinal parasites</th>
<th>Females n=202</th>
<th>Males n=182</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Entamoeba histolytica</em></td>
<td>30 (14.9%)</td>
<td>35 (19.2%)</td>
</tr>
<tr>
<td><em>Giardia lamblia</em></td>
<td>5 (2.5%)</td>
<td>3 (1.6%)</td>
</tr>
<tr>
<td><strong>Total protozoa</strong></td>
<td><strong>35 (17.3%)</strong></td>
<td><strong>38 (20.9%)</strong></td>
</tr>
<tr>
<td><em>Ascaris lumbricoides</em></td>
<td>19 (9.4%)</td>
<td>21 (11.5%)</td>
</tr>
<tr>
<td><em>Trichuris trichiura</em></td>
<td>4 (2.0%)</td>
<td>7 (3.8%)</td>
</tr>
<tr>
<td>Hookworms</td>
<td>9 (4.5%)</td>
<td>6 (3.3%)</td>
</tr>
<tr>
<td><strong>Total helminthes</strong></td>
<td><strong>32 (15.8%)</strong></td>
<td><strong>34 (18.7%)</strong></td>
</tr>
<tr>
<td><strong>Total intestinal parasites</strong></td>
<td><strong>67 (33.2%)</strong></td>
<td><strong>72 (39.6%)</strong></td>
</tr>
</tbody>
</table>

Infection rate between male and female students was not significantly different ($\chi^2=3.92$, $P=0.56$ df=5).

Table 4.6 shows the intensities of helminths infections among students. Quantification of the intensity of helminths infections was based epg and categorized as light (1-100 epg), moderate (101-400 epg) and heavy (400 ≥ epg) (Cheesebrough, 2001). Most of the helminths infections were of light intensities (56.1%), with *Ascaris lumbricoides* having the highest proportion of light infections at 65.0%. The overall helminths infection rate of light and moderate intensities was significantly different ($\chi^2=13.66$, $p=0.006$, df=4). Similarly there was significant difference between the light and moderate infections due to *Ascaris lumbricoides* ($\chi^2=104.2$, $p=0.009$, df=4). Most *Trichuris trichiura* infections were of moderate intensities (54.5%), these were significantly different with heavy intensities of infection ($\chi^2=16.8$, $p=0.003$, df=4).
Table 4.6 Intensities of helminths infections among students

<table>
<thead>
<tr>
<th>Parasites</th>
<th>Intensities</th>
<th>Light (1-100 epg)</th>
<th>Moderate (101-400 epg)</th>
<th>Heavy (≥400 epg)</th>
<th>ANOVA P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Ascaris lumbricoides</em></td>
<td></td>
<td>26 (65.0%)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4 (10.0%)</td>
<td>10 (25.0%)</td>
<td>$\chi^2=104.2$, P=0.009, df=4</td>
</tr>
<tr>
<td>Hook worms</td>
<td></td>
<td>7 (46.7%)</td>
<td>2 (13.3%)</td>
<td>6 (40.0%)</td>
<td>$\chi^2=32.7$, P=0.34, df=4</td>
</tr>
<tr>
<td><em>Trichuris trichiura</em></td>
<td></td>
<td>4 (36.4%)</td>
<td>6 (54.5%)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1 (9.0%)</td>
<td>$\chi^2=16.8$, P=0.003, df=4</td>
</tr>
<tr>
<td>Total infections</td>
<td></td>
<td>37 (56.1%)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>12 (18.2%)</td>
<td>17 (25.8%)</td>
<td>$\chi^2=13.66$, P=0.006, df=4</td>
</tr>
</tbody>
</table>

<sup>a, b, and c</sup> shows results that were statistically significant.

4.2 Co-infection of geo helminths and intestinal protozoa among students

Most of the infections among students were of single species. However, 3.6% of the students tested had multiple infections (Table 4.7). The most common co-infections were of different helminths species while the only protozoa and helminths co-infection recorded was between *Ascaris lumbricoides* and *Entamoeba histolytica* at 35.7%. Day secondary schools had significantly higher co-infection rate of 8.6% compared to boarding secondary schools at 1.1% ($\chi^2=15.138$, p=0.004, df=2). Co-infections of *Ascaris lumbricoides* and hookworms were recorded only in day secondary schools.
Table 4.7 Co-infection rates for helminths and protozoa in day and boarding schools.

<table>
<thead>
<tr>
<th>Type of school</th>
<th>a¹</th>
<th>a²</th>
<th>a³</th>
<th>a⁴</th>
<th>Number infected</th>
<th>Totals</th>
<th>ANOVA p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>11(8.6%)</td>
<td>128</td>
<td>χ²=15.138, p=0.004, df=2</td>
</tr>
<tr>
<td>Boarding</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>3(1.1%)</td>
<td>256</td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>5(35.7%)</td>
<td>4(28.6%)</td>
<td>3(21.4%)</td>
<td>2(14.3%)</td>
<td>14(3.6%)</td>
<td>384</td>
<td></td>
</tr>
</tbody>
</table>

a¹ - A. lumbricoides and E. histolytica  
a² - A. lumbricoides and hookworm  
a³ - Hookworm and T. Trichiura  
a⁴ - A. lumbricoides and T. trichiura

When comparing co-infection rates between sexes, table 4.8 indicates that male students recorded a slightly higher overall multiple infection rates than females at 9.7% and 9.0% respectively, although the difference was not significant (χ²=5.15, p=0.16, df=2). Co-infection between Ascaris lumbricoides and Trichuris trichiura was only found in male students.
Table 4.8 Co-infection rates of helminths and protozoa among male and female students

<table>
<thead>
<tr>
<th>Intestinal parasites</th>
<th>Males</th>
<th>Females</th>
<th>Total co-infection</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Ascaris lumbricoides</em> and <em>Entamoeba histolytica</em></td>
<td>2 (15.4%)</td>
<td>3 (23.0%)</td>
<td>5 (38.5%)</td>
</tr>
<tr>
<td><em>Ascaris lumbricoides</em> and Hookworms</td>
<td>3 (23.0%)</td>
<td>1 (7.7%)</td>
<td>4 (30.8%)</td>
</tr>
<tr>
<td>Hookworms and <em>Trichuris trichiura</em></td>
<td>1 (0%)</td>
<td>2 (15.4%)</td>
<td>3 (15.4%)</td>
</tr>
<tr>
<td><em>Ascaris lumbricoides</em> and <em>Trichuris trichiura</em></td>
<td>2 (15.4%)</td>
<td>0 (0%)</td>
<td>2 (15.4%)</td>
</tr>
<tr>
<td><strong>Total co-infections</strong></td>
<td><strong>7 (9.7%)</strong></td>
<td><strong>6 (9.0%)</strong></td>
<td><strong>14 (3.6%)</strong></td>
</tr>
</tbody>
</table>

Co-infection rates between male and female students was not statistically significant $\chi^2=5.15$, $p=0.16$, df=2.

4.3 Transmission risks associated with protozoa and helminths infections among students.

The from questionnaires (Table 4.9) shows the risk factors of intestinal parasitic infections in relation to environmental sanitation within the homes of students. The study found that majority of the students used unimproved water sources (57.0%). The students using unimproved water sources such as dug out wells, rivers and streams were four times predisposed to intestinal parasitic infections compared to those using improved water sources (OR=4.02, CI (2.57-6.92)).

Most of the students (76%) used pit latrines in homes as opposed to flush toilets. The study showed that 54.7% were infested with flies and / or cockroaches. These two factors did not significantly influence infection with intestinal parasites (OR=1.034, CI (0.29-4.32) and (OR=0.7, CI (0.19-4.32) respectively.
Majority of the students (64.9%) were involved in farming activities at home. Increased risk of infection was found in students who were involved in farming activities compared to those not involved in farming activities (OR=3.07, CI (2.19-4.32)).

Table 4.9 Transmission factors of intestinal parasites in relation to home environment.

<table>
<thead>
<tr>
<th>Environmental factors</th>
<th>Number of students</th>
<th>Infected students</th>
<th>Odds ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved water sources</td>
<td>165 (43.0%)</td>
<td>16 (9.7%)</td>
<td>OR=4.02, CI (2.57-6.92),</td>
</tr>
<tr>
<td>Unimproved water sources</td>
<td>219 (57.0%)a</td>
<td>119 (54.3%)</td>
<td></td>
</tr>
<tr>
<td>Pit latrines</td>
<td>292 (76.0%)</td>
<td>106 (36.3%)</td>
<td>OR=1.03, CI (0.29-4.32)</td>
</tr>
<tr>
<td>Flush latrines</td>
<td>92 (24.0%)</td>
<td>24 (26.1%)</td>
<td></td>
</tr>
<tr>
<td>Presence flies and/or cockroaches in sanitary facilities</td>
<td>210 (54.7%)</td>
<td>72 (34.3%)</td>
<td>OR=0.70, CI (0.19-4.32)</td>
</tr>
<tr>
<td>Absence of flies and/or cockroaches in sanitary facilities</td>
<td>174 (45.3%)</td>
<td>60 (34.5%)</td>
<td></td>
</tr>
<tr>
<td>Involvement in farming activities</td>
<td>249 (64.8%)b</td>
<td>70 (51.9%)</td>
<td>OR=3.07, CI (2.19-4.32)</td>
</tr>
<tr>
<td>Not involvement in farming activities</td>
<td>135 (35.2%)</td>
<td>67 (26.9%)</td>
<td></td>
</tr>
</tbody>
</table>

a and b shows factors that were significantly associated with intestinal parasitic infections
All the four schools sampled obtained water from unimproved sources especially from rivers and dugout wells (Table 4.10). Muthambi and Kajiunduthi secondary schools had hand washing facilities close to the latrines and dining facilities, while Munga and Kyeni did not have. None of the four school sampled provided students with soap for washing hand after visiting toilets or before meals.

All the four schools sampled had pit latrines for the students. In addition Muthambi Girls had flush toilets within the dormitories. Students in all the schools cited seeing flies and cockroaches in the latrines and toilets.

The schools sampled obtained their fruits and vegetables from the local market. The students in Kyeni and Munga secondary schools were involved in farming activities while in school, whereas those of Muthambi and Kajiunduthi were not.
Table 4.10 Environmental factors that influence transmission of intestinal parasites within the schools.

<table>
<thead>
<tr>
<th>School Risk factors</th>
<th>Conditions</th>
<th>Kyeni</th>
<th>Munga</th>
<th>Muthambi</th>
<th>Kajiunduthi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water sources</td>
<td>Improved</td>
<td>×</td>
<td>×</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td></td>
<td>Unimproved</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Provision of safe drinking water</td>
<td>Provide</td>
<td>×</td>
<td>×</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td></td>
<td>Don’t provide</td>
<td>√</td>
<td>√</td>
<td>×</td>
<td>√</td>
</tr>
<tr>
<td>Provision of hand washing facilities</td>
<td>Provide</td>
<td>×</td>
<td>×</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td></td>
<td>Don’t provide</td>
<td>√</td>
<td>√</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td>Provision of soap</td>
<td>Provide</td>
<td>×</td>
<td>×</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td></td>
<td>Don’t provide</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Type of sanitary facilities</td>
<td>Pit latrines</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td></td>
<td>Flush toilets</td>
<td>×</td>
<td>×</td>
<td>√</td>
<td>×</td>
</tr>
<tr>
<td>Flies and / or cockroaches in sanitary facilities</td>
<td>Present</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td></td>
<td>Absence</td>
<td>×</td>
<td>×</td>
<td>×</td>
<td>√</td>
</tr>
<tr>
<td>Sources of fruits &amp; vegetables</td>
<td>Market</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td></td>
<td>School farm</td>
<td>×</td>
<td>×</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td>Farming activities</td>
<td>Involved</td>
<td>√</td>
<td>√</td>
<td>×</td>
<td>√</td>
</tr>
<tr>
<td></td>
<td>Not involved</td>
<td>×</td>
<td>×</td>
<td>√</td>
<td>√</td>
</tr>
</tbody>
</table>

√ indicates positive responses  × Indicates negative responses
Table 4.11 shows the personal hygiene practices that influenced transmission of intestinal parasitic infections. The results showed that only 17.7% of the students boiled drinking water. Boiling drinking water was significantly associated with reduced likelihood of infection with intestinal parasites (OR=3.3, CI (0.19-5.6). A large number of students did not wash hand after visiting toilets or before meals. Of these, 54.9% were infected with intestinal parasites. The students who washed their hands with soap after visiting the toilets and before meals were less likely to be infected with intestinal parasites (OR=2.96, CI (2.07-4.21). However washing hands with water only without soap did not significantly reduce infections with intestinal parasites (OR=0.87, CI (0.58-1.29).

About 50.3% of the students washed fruits before eating. This significantly reduced their chance of infection with intestinal parasites (OR=5.8, CI (3.82-8.94). About 50.8% of the students eat food sold in open places, this practice was however not associated with infection with intestinal parasites (OR=0.45, CI (0.01-1.72).

It was observed that, 67.4% of the students wore shoes frequently while working in farms or when walking on wet grounds, this significantly reduced their chance of infection with intestinal parasitic infections especially that of hookworms (OR=2.54, CI (1.87-3.45).

Only a small proportion of students (8.3%) frequently bathed or swam in rivers, streams or pools. This practice did not influence the chances of infection with intestinal parasites among the students (OR=1.06, CI (0.50-2.22).
Table 4.11 Personal hygiene practices that influence transmission of intestinal parasites.

<table>
<thead>
<tr>
<th>Personal hygienic practices</th>
<th>Number of students</th>
<th>Students infected</th>
<th>Odds ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiling drinking water</td>
<td>68(17.7%)</td>
<td>27(39.7%)</td>
<td>OR=3.3, CI (0.19-5.6)</td>
</tr>
<tr>
<td>Not boiling drinking water</td>
<td><strong>316(82.3%)</strong></td>
<td>212(67.1%)</td>
<td></td>
</tr>
<tr>
<td>Washing hands after visiting toilets</td>
<td>189(49.2%)</td>
<td>97(51.3%)</td>
<td>OR=0.87, CI (0.58-1.29)</td>
</tr>
<tr>
<td>Not washing hands after visiting toilets</td>
<td>195(50.8%)</td>
<td>107(54.9%)</td>
<td></td>
</tr>
<tr>
<td>Washing hands with soap</td>
<td>120(31.3%)</td>
<td>42(35.0%)</td>
<td>OR=2.96, CI (2.07-4.21)</td>
</tr>
<tr>
<td>Not washing hands with soap</td>
<td><strong>264(68.8%)</strong></td>
<td>133(50.4%)</td>
<td></td>
</tr>
<tr>
<td>Washing fruits before eating</td>
<td>193(50.3%)</td>
<td>58(30.1%)</td>
<td>OR=5.8, CI (3.82-8.94)</td>
</tr>
<tr>
<td>Not washing fruits before eating</td>
<td>191(49.7%)</td>
<td>81(42.4%)</td>
<td></td>
</tr>
<tr>
<td>Eating food sold in open places</td>
<td>195(50.8%)</td>
<td>107(54.9%)</td>
<td>OR=0.45, CI (0.01-1.72)</td>
</tr>
<tr>
<td>Not eating food sold in open places</td>
<td>189(49.2%)</td>
<td>97(51.3%)</td>
<td></td>
</tr>
<tr>
<td>Wearing shoes frequently</td>
<td>259(67.4%)</td>
<td>99(79.2%)</td>
<td></td>
</tr>
<tr>
<td>Not wearing shoes frequently</td>
<td>125(32.6%)</td>
<td><strong>113(43.6%)</strong></td>
<td>OR=2.54, CI (1.87-3.45)</td>
</tr>
<tr>
<td>Swimming in streams/rivers/pools</td>
<td>32(8.3%)</td>
<td>12(37.5%)</td>
<td>OR=1.06, CI (0.50-2.22)</td>
</tr>
<tr>
<td>Not swimming in streams/rivers/pools</td>
<td>352(91.7%)</td>
<td>127(36.1%)</td>
<td></td>
</tr>
</tbody>
</table>

a, b, c and d show factors that were significantly associated with infection with intestinal parasites.
CHAPTER FIVE

DISCUSSION

5.1 Occurrence levels of geoheeminths and intestinal protozoa infections among students

Most of the existing data on intestinal parasitic infections has been based on school age children of 5-10 years old. The current study assessed the occurrence of intestinal parasitic infections in secondary school students aged between 14 and 19 years in Form one, two, and three in four secondary schools in Maara Sub-County, Tharaka-Nithi County.

The overall infection rate for both helminths and protozoa was 36.2%. The presence of intestinal protozoa and helminths infections among secondary school students could be attributed to favorable climatic conditions prevailing in the area, poor hygiene among the students. Poor environmental sanitation and improper hygiene leads to ingestion of helminths eggs and / or protozoa cysts (Ezeamama et al., 2005). For example 82.3% did not boil drinking water while 68.8% did not wash hands with soap in school and at home all the time hence increasing the chances of infection with intestinal parasites.

Epidemiological studies indicate that favorable environmental conditions enhance embryonation of helminths eggs resulting to higher infection rates (Vigor et al., 2002). The study area has annual temperature range of between 14°C and 34°C and receives about 500 mm- 1050 mm of rainfall per year (KMD, 2013). This creates warm moist conditions required for embryonation of helminths eggs especially those of Ascaris lumbricoides (WHO, 2011). The study showed that 82.3% of the students did not boil drinking water while 68.8% did not wash hand with soap in school and at home.
home all the time increasing the chances of ingestion of helminths eggs and / or protozoan cysts.

The most common types of intestinal parasitic infections among the secondary school students studied were protozoa; *Entamoeba histolytica* (16.9%) and *Giardia lamblia* (2.8%) and the helminths were; *Ascaris lumbricoides* (10.4%), hookworms (3.9%) and *Trichuris trichiura* (2.9%). The same types of intestinal parasites were identified in other studies carried out in Kenya. For example, Kihara et al., (2009), found the same parasites in addition to schistosomes in a study in Mwea.

The occurrence of high levels of *Ascaris lumbricoides* infections in this study could be due to involvement in farming activities. The students work in farms after school hours and during the school holidays hence there is frequent contact with the soil. This together with poor hygiene leads to ingestion of helminths eggs (Zaglool et al., 2011). Abrarau et al., (2013) reported high infection rate due to frequent contact with the soil and poor hand washing behavior allowing ingestion of helminths eggs.

*Ascaris lumbricoides* eggs are coated with mucopolysaccharides that render them adhesive to a wide variety of surfaces such as door handles, dust, vegetables, paper money and coins hence easily ingested (Sayasone et al., 2011). Studies done in Brazil indicated higher helminths infection rate of 18.5% among children whose families were involved in farming activities compared to 11.4% among children from families that were not involved in farming (Scolari et al., 2000).

The presence of hookworms among the study population could be due to the fact that students work in the farms without protective gear and also do not wear shoes frequently while at home (32.6%). This potentially allows penetration of filariform larvae through the skin especially on the foot and hands (Ezeamama et al., 2005).
The presence of *Giardia lamblia* infections among the study population could be explained in terms of the water sources both in schools and at homes. Most of the streams originate from Mount Kenya forest hence could be contaminated with faeces from wild animals. *Giardia lamblia* cysts have been known to exist in clear mountain stream. This is mainly from animal contamination and is the main cause of diarrhoea among campers (Roberts and Janovy, 2009). Studies conducted elsewhere demonstrated that wild animals could also be infected with *Giardia lamblia* hence could be source of contamination in forest springs water (Heckendorn *et al*., 2002). The contaminated water is used for drinking, washing clothes and other domestic uses.

The overall occurrence of protozoa infections among students was significantly higher than that of helminths ($\chi^2=94.2$, $p=0.01$, df=1). Similar studies on the prevalence of intestinal parasites conducted on school children showed protozoa infections more common than helminths (Shreshtha *et al*., 2012). This indicates that most of the infections were due to poor personal hygiene and environmental contamination of water sources as previously reported (Caler and Lorenzi, 2010). One reason for this is that the transfer of protozoa cysts is much easier than of eggs or larvae of helminths since the infections are mainly transferred through drinking water (Roberts and Janovy, 2009). Studies done in Western Kenya indicated that boiling drinking water reduced intestinal protozoa infections by up to 32% among school children (Thiong’o *et al*., 2009).

The study used microscopy method in identification of *Entamoeba histolytica* cysts and trophozoites in the stool specimen. This method, however, does not distinguish between *Entamoeba histolytica* and commensal *Entamoeba dispar* (Murray *et al*., 2005).
Kyeni mixed day school had the highest infection rate (42.2%) compared to the other three schools. This could be due to its location within lower regions of Mwimbi division of Maara Sub-County (Appendix I). In this region, farming is intensified due to availability of farmland and water shortages are experienced making it difficult to maintain proper hygiene.

The intestinal parasitic infections were significantly higher in day schools than boarding schools ($\chi^2=249$, $p=0.0$, df=2). This could be because day school students are frequently involved in farming activities after school and during weekends compared to those in boarding schools who do it only during school holidays. The boarding schools also provided students with hand washing facilities close to the latrines and dining halls. This is likely to promote washing of hands after using the latrines and / or before meals. Failure of schools to provide hand washing facilities and soap makes it difficult to maintain proper hygiene, which potentially leads to higher infection rates in day schools; similar as reported by WHO (2013).

The two boarding schools sampled had flush toilets in addition to pit latrines whereas day secondary schools had only pit latrines. With adequate water, flush toilets are known to reduce intestinal parasitic infections since the faeces are not exposed to vectors which mechanically transmit parasites to food (Tarko et al., 2013).

According to WHO (2010), infection rates vary by age groups in which prevalence is higher in lower age groups. In this study slightly lower levels of infection (33.1%) were recorded among Form one students compared to those in Form two and three at 37.5% and 38.1% respectively. This could be because Form one students may have been treated during the medical examination required before joining secondary school. The other reason could be that the Form three students are older hence may
have been exposed to variety of contaminated environments. The results contradicts with studies done in Western Kenya that indicated a higher infection rate among students aged below ten years (47%) compared to those aged above ten years (30%) (Thiong’o et al., 2009).

In this study, the relationship between intestinal parasitic infections and sex was not statistically significant ($\chi^2=3.92$, $p=0.56$, df=1), although male students had a slightly higher infection rate (39.6%) than the females (33.2%). This could be due to the fact that male and female students generally engaged in the same social economic activities hence were exposed to similar risk factors within their environment. The slightly higher infection levels in male students could be because the female students are more likely to practice hand washing behavior frequently when doing domestic chores (WHO, 2011).

Other studies for example, done in Bondo District, Kenya among students aged between 5-20 years showed a higher infection rate in boys than in girls at 39.0% compared to 34.5%, although the difference was not statistically significant (Thiongo et al., 2009). Studies done in China indicated a higher infection rate 53% among the male students compared to 39% among female students aged between 10-23 years (Wang et al., 2012). This difference with the current study could be due to prevailing climatic and social conditions in the areas of study.

The study showed that there was significant difference in the intensities of helminths infections ($\chi^2=13.6$, $p=0.01$, df=4), with 56.1% of the infections being of light intensities. These findings contradict those obtained in a study done in Nairobi, Kenya, in which most of the school children had heavy intensities of helminths
infections (Mutuku et al., 2008). The difference in the studies could be due to the fact that helminthiasis is endemic in the region of later study.

5.2 Co-infection levels of geohelminths and intestinal protozoa among students

Multiple infections of protozoa and helminths existed in only 3.6% of the students sampled. Several investigations suggest that this may have far reaching effects on the health of such individuals as they may suffer multiple morbidity (Bogochi et al., 2006). Such children are also known to have poorer academic scores compared to children with only a single infection (Boboris et al., 2003). Polyparasitism may result since an already established parasite through its activities may create a suitable environment within the host for other parasitic infections (Luskigman et al., 2012). Epidemiological studies indicate that many factors contribute to polyparasitism including lack of access to clean drinking water and poor sanitary facilities, as well as low hygienic conditions (Asoulo and Ofoezie, 2003).

The slightly higher co-infection rate in day schools (8.6%) compared to boarding schools (1.1%), could be attributed to the fact that students in day schools are exposed to a variety of environments since they are likely to visit many places after schools hence may to acquire and transmit infections to other students. Intestinal parasitic infections are known to be more common in institutions where there is inadequate sanitation and there is shortage of safe drinking water (Strunz et al., 2013).

The highest co-infection rate recorded in this study was between Ascaris lumbricoides and Entamoeba histolytica at 35.7%. This could be attributed to social and behavioral factors such as involvement in farming, drinking contaminated water and failure to wash hand after toilet use and before eating. Sayasone et al., (2000) obtained
comparable results of 39.4% co-infection rate between *Ascaris lumbricoides* and *Entamoeba histolytica*.

### 5.3 Transmission risks of intestinal protozoa and geohelminths among students

The study indicates that 57% of students used unimproved water sources in their homes. These students were found to have higher protozoa infections than those using improved water sources. In addition, all the schools sampled did not provide safe drinking water for the students. These factors could have lead to increase in transmission of intestinal parasites especially *Entamoeba histolytica* and *Giardia lamblia* that are commonly transmitted through fecal contamination of drinking water (Caler and Lorenzi, 2010).

The study showed that all the four schools sampled had pit latrines as opposed to flush toilets. Construction of toilets and proper usage has been suggested as an effective control measure of intestinal parasites. In circumstances where toilets are not easily cleaned and the water table is high helminths infections may not be effectively controlled (De Silva et al., 2003). The study reported presence of flies and/or cockroaches in pit latrine both at home and in school, indicating that they were not well maintained hygienically. These vectors potentially carry the helminths cysts mechanically and deposited them on food leading to infections (Gambao et al., 2003). They could also be a source of infection for the latrine users especially if they do not wash hands after latrine use. Studies done in Nigeria indicated that filthy houseflies and cockroaches mechanically carry parasites cysts and eggs into food; hence increasing chances of infection (Damen et al., 2011).

The study indicated that students involved in farming activities (64.9%) were 3.07 more likely to get infected with intestinal parasites compared to those who were not
involved (OR= 3.07, CI (2.19-4.32). This is because the helminths eggs adhere to hands especially on the finger nails thus can be transferred to other surfaces or may be ingested leading to infection. Studies done in Argentina recorded higher intestinal parasitic infections among farming communities due to ingestion of eggs and penetration of the larvae through the skin (Ngonyo et al., 2009).

Wearing of protective clothing such as gloves and gum boots while working on farms prevents the penetration of hookworm, *Ancylostoma duodenale*, *Necator americanus* and *Strongyloides stercoralis* larvae through the skin (Strunz et al., 2013). In addition farm workers are advised to wash their hands thoroughly with soap after work and before eating to avoid ingestion of the helminths eggs (WHO, 2010).

The current study showed that infection rates were significantly lower among students who washed their hands with soap and water after visiting toilets (OR= 3.07, CI (2.07-4.21). Soap has abrasive properties that help to removes parasites’ egg and/or cysts that may have adhered to the hands preventing ingestion (WHO, 2010).

Washing hands with water only without soap did not significantly reduce the risk of acquiring intestinal parasitic infections in the current study (OR=0.86, CI (0.58-1.29). This could be explained due to the possibility that the water used was contaminated. Studies done in Ethiopia (Abrarau et al., 2013; Tarko et al., 2013) showed that people who rarely washed their hands with soap and water after field work had increased risk of intestinal parasitic infection compared to those who frequently did. Failure to wash hands after visiting toilets and before meals increases the chances of contaminating food and water with protozoan and helminths cysts resulting to them being ingested (Wang et al., 2012).
Students who drank water that was not boiled nor treated were 3.3 times likely to get infected with intestinal parasites compared to those who did not (OR = 3.3, CI (0.19-5.6). According to WHO (2010) boiled water is usually safe since the process kills protozoan cysts, helminths larvae and egg. Boiling of water in developing countries can be made difficult by shortage of fuel especially firewood (WHO, 2011). Chlorine treatment of drinking water is effective but is more likely in piped water system. In this study, the schools had piped water; however, the water was not treated. The water treatment systems can however be considered ineffective if the levels of chlorine are insufficient to kill the pathogen cysts. For example, *Giardia lamblia* cysts are known to resist standard levels of chlorine in water (Roberts and Janovy, 2009). Higher levels of chlorine are effective but the water must be de-chlorinated before use (Quinnel, 2003).

This study indicated that failure to wear shoes increased the likeliness of infection with intestinal parasites by 2.5 times (OR = 2.54, CI (1.87-3.45). The students were exposed to hookworm infections since the larvae penetrated though the skin especially on the feet (Markell *et al.*, 2004). Failure to wear shoes especially in moist soils promotes entry of filariform larvae of hookworms and *Strongyloides stercoralis* (Odiere and Opisa, 2011). Secondary school students always wear shoes while in school as part of their uniform, however, the study indicated that they do not wear shoes frequently (32.6%) while at homes especially while working in the farms. Day school students may carry fecally contaminated mud or soil from their homes on their shoes, hence introducing helminths infections to the school environment. Pinar *et al.*, (2004) indicated increased risk of hookworm infections among students who did not wear shoes frequently.
The study showed that failure to wash fruits before eating increased the chances of infections with intestinal parasites by 5.8 times (OR=5.8, CI (3.82-8.94). Fruits such as mangoes and avocados are common in the area. They are mostly collected from the ground surfaces thus are likely to be contaminated with human faeces containing helminths eggs especially those of *Ascaris lumbricoides*. The eggs may be ingested by human if the fruits are not properly washed or peeled (Capello, 2004).

In the current study, 54.9% of the students who ate food sold in open places. These had a higher chances of infection with intestinal parasites (54.9%) compared to 51.3% of those who did not. This practice was not significantly associated with intestinal parasites (OR=0.45, CI (0.01-1.72). The parasites eggs and / cysts found on these foods are likely to be destroyed by the heat during preparation (Nam *et al.*, 2012).

The study showed that only 8.3% of the students bathed or swam in local rivers, however, those infected were 37.5%. There was almost equal chance of infection with intestinal parasites among students who swim and those that did not swim in rivers (OR=1.06, CI (0.50-2.22). This is an indicator that combinations of various risk factors in addition to swimming in rivers may have led to intestinal parasites infections among the students. Studies done in Nepal indicated that students who swam in contaminated rivers had increased incidences of hookworm infections (34%) compared to (28.4%) who did not (Shreshtha *et al.*, 2012). Studies have shown that hookworm larva and those of schistosomes easily penetrated the body through the skin when people get in contact with contaminated waters (Luskigman *et al.*, 2012).
CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusions

i. The overall occurrence of both helminths and protozoa infections among students was 36.2%. The helminths infection rates were 17.2% and protozoa were 19.0%. The most common helminths infection was *Ascaris lumbricoides* at 10.4% which was similar across the four schools. Hookworm infection rate was 3.9% and the least prevalent was *Trichiuris trichiura* at 2.9%. The most common protozoan infection was due to *Entamoeba histolytica* at 16.9% while *Giardia lamblia* infections were 2.8%.

ii. Most of the infections among students were single protozoa and helminths species infections at 96.4% while multiple infections between helminths-helminths species and helminths,protozoa were 3.6%. The highest co-infection rate was between *Ascaris lumbricoides* and *Entamoeba histolytica* at 35.7%.

iii. The most important environmental factors predisposing students to intestinal parasitic infections were drinking unsafe water and involvement in farming. The personal hygiene factors predisposing students to infection with intestinal parasites were failure to boil drinking water, failure to wash hands with soap after visiting toilets, failure to wash fruits before eating and failure to wear shoes frequently.

iv. It was evident of transmission risk factors of intestinal parasites among students in both day and boarding secondary schools.
6.2 Recommendations

i. The County medical services should conduct deworming programs in schools once every three months according to WHO (2012) together with screening and treatment of protozoa infections. The public health sector should provide health education and promote environmental sanitation in schools and the communities.

ii. The school Board of Management should provide hand washing facilities within the schools.

iii. The ministry of public health should conduct health education on environmental sanitation and personal hygiene practices among secondary school students.

6.3 Further research

This study recommends further studies on;

i. Intestinal parasitic infection rates assessing the seasonality of transmission.

ii. Analysis of drinking water in homes and schools for cysts and / or helminths eggs to assess its safety.
REFERENCES


APPENDICES

Appendix I: Map of Kenya showing the location of Tharaka-Nithi County.

Inset; Map of Maara Sub-County showing the divisions studied

Adapted from Google maps, 2016.
Appendix II: Questionnaire

INSTRUCTIONS: Please fill in this questionnaire as accurately as possible by ticking the correct answer. The information in the questionnaire will be treated with confidentiality and will be used only for this study.

Part A: BACKGROUND CHARACTERISTICS/ DEMOGRAPHIC DATA

Random number of subject

School

1. Sex
   Male ( ) Female ( )

2. Class
   Form 1 ( ) Form 2 ( ) Form 3 ( )

3. County…………………… District…………………….. Location……………

4. Age……………………

5. When did you last take antihelmintic and /or anti protozoa medication?
   This month ( ) Last month ( )
   Last two months ( ) More than three months ago ( )

Part B: ENVIRONMENTAL DATA

6. Where does your family get water for domestic use?
   Streams/River ( ) Tap water ( )
   Borehole ( ) Rain water ( )
7. Do you carry out farming activities like weeding and digging on the farms?

Always ( )  Sometimes ( )  Rarely ( )  Never ( )

8. Do you wear protective clothing such as gloves and gum boots while weeding and digging on the farms?

Always ( )  Sometimes ( )  Rarely ( )  Never ( )

9. What type of toilets do you use while at home?

Pit latrine ( )  Flush toilet ( )

10. Do you see flies or cockroaches in the toilet/latrine?

Yes ( )  No ( )

**PART C; PERSONAL HYGIENE PRACTICES**

11. Do you drink water that is not boiled?

Always ( )  Sometimes ( )  Rarely ( )  Never ( )

12. Do you boil drinking water while at home?

Always ( )  Sometimes ( )  Rarely ( )  Never ( )

13. How often do you wash hands after using the toilet?

Always ( )  Sometimes ( )  Rarely ( )  Never ( )

14. (a). Do you wash hands before taking any food or after using toilets / latrine?

Always ( )  Sometimes ( )  Rarely ( )  Never ( )
(b). If yes, do you wash your hands with soap?

Always ( )  Sometimes ( )  Rarely ( )  Never ( )

15. Do you buy and eat foods and/or fruits such as yams, mangoes, maize that are prepared and sold along the road?

Always ( )  Sometimes ( )  Rarely ( )  Never ( )

16. Where do you mostly obtain your fruits and vegetables?

Farm/shamba ( )  market ( )

17. Do you wash fruits before eating?

Always ( )  Sometimes ( )  Rarely ( )  Never ( )

18. Do you walk barefoot/ without shoes on mud or during rainy seasons?

Always ( )  Sometimes ( )  Rarely ( )  Never ( )

19. Do you bath or go swimming in the rivers, swamps?

Always ( )  Sometimes ( )  Rarely ( )  Never ( )
Appendix III: Check list for environmental sanitation in schools

1. Name of school

2. Type of school  a) Day ( )  Boarding ( )
   Pure girls’ ( )  Pure boys’ ( )  Mixed boys and girls ( )

3. Total number of students
   a) Form one……..  b) Form two……..  c) Form three……..

4. What is the source of water in your school?
   a) Rivers ( )  b) Piped ( )  c) Dugout wells ( )  d) Rain ( )

5. Do you boil or treat drinking water for the students?
   Always ( )  Sometimes ( )  Rarely ( )  Never ( )

6. Do you have hand washing facilities such as water taps close to toilets and dining hall?
   a) Yes ( )  b) No ( )

7. Does the school provide soap in the hand washing facilities?
   Always ( )  Sometimes ( )  Rarely ( )  Never ( )

8. What type of sanitary facilities does the school have for the students?
   a) Pit latrines ( )  b) Flush toilets ( )  c) Pit latrines and flush toilets ( )

9. Do you see flies and / cockroaches in the school toilets / latrines?
   a) Yes ( )  b) No ( )

10. Where does the school mostly obtain fruits and vegetables from?
    a) School farm ( )  b) Markets ( )

11. Do students participate in farming activities within the school farm?
    Always ( )  Sometimes ( )  Rarely ( )  Never ( )
Appendix IV: Informed consent for students above 18 years

I, Mr/Miss………………………………………….., being over 18 years do hereby agree to participate in the intended research. I have been made to understand the implications and benefits of the tests and treatment. I understand that I may withdraw from the research at any time, without any penalty. All the above conditions have been explained to me in Kiswahili/English language which I am fluent.

Students name…………………………………………………………………

Signature……………………………….Date…………………………………

Witness name……………………………………………………………………

Witness signature………………………Date…………………………………..
Appendix V: Informed consent for students below 18 years

I, Mr/Mrs/Miss/Ms……………………….., being an adult and the lawful guardian of,
………………………..do hereby allow her/him to participate in the intended study. I
have also understood the implications and benefits of the study. I understand that I
may withdraw my child from the research at any time, without any penalty. All the
above conditions have been explained to me in Kiswahili/English language which I
am fluent.

Guardian’s name……………………………………………………………………

Signature………………………Date……………………………………

Witness name……………………………………………………………………

Witness signature……………………Date……………………………………
Appendix VI: Ethical clearance letter

ETHICAL CLEARANCE BY BETHSAIDA HOSPITAL

BETHSAIDA HOSPITAL.
P.O BOX 243,
CHOGORIA,
9/05/2013.

TO,
KELLEN K. RIUNGU
P.O BOX CHOGORIA,

RE: ETHICAL CLEARANCE FOR RESEARCH.

This is to inform you that our review committee went through your proposal and considered you to conduct research at our hospital laboratory. Our technical team at the hospital laboratory will assist you to ensure that all the recommended standards and procedures are followed in the course of your research process.

Thank you.

Dr Kenneth Micheni D.
Medical superintendent,
Mwangarimwe Sub-County Hospital,
CC.
Laboratory in-charge.
Appendix VII: A sample of permission letter from school.

LETTER OF PERMISSION TO COLLECT DATA FROM THE SCHOOL

MUNGA DAY SECONDARY SCHOOL.
P.O BOX 240,
CHOGORIA,
12/05/2013

TO,

KELLEN K. RIUNGU
KENYATTA UNIVERSITY
I56/CE/22425/1O

RE-; PERMISSION TO COLLECT RESEARCH DATA
This is to certify that the above named Master of Science student has been permitted to collect data from the school. This, as part of her Master’s of Science program. Please accord her the necessary assistance.

Yours Faithfully

The principal.