PREVALENCE OF INTESTINAL PARASITIC INFECTIONS AND TRANSMISSION RISK FACTORS IN PRIMARY SCHOOL CHILDREN IN MBEERE NORTH SUB-COUNTY, EMBU COUNTY, KENYA

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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

MAY, 2019
DECLARATION

This thesis is my original work and has not been presented for the award of a degree or other awards in any other University

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DEDICATION

This thesis is dedicated to my family and friends; the ones that have stood with me all the way and the ones I have lost along the way.
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DEFINITION OF OPERATIONAL TERMS

Amoebiasis  A protozoan disease caused by Entamoeba histolytica, characterized by ulceration of the large intestine.

Dysentery  An inflammatory disease of the intestine especially the colon, characterized by severe diarrhea containing mucus and / or blood in stool.

Hookworm  Maybe used to mean Ancylostoma duodenale or Necator americanus infection, a type of intestinal parasitic worm.

Prevalence  Proportion of a population affected by a disease at a particular time.

Risk factors  Factors highly associated with increased chances of disease development.

Sanitary  Free from elements such as filth or pathogens that endanger health.

Dry river bed well  Well dug at the base of dried river sand.
ABBREVIATIONS AND ACRONYMS

CDC  Centre for disease control
CI   Confidence interval
GBD  Global Burden of Disease
GIT  Gastrointestinal tract
GoK  Government of Kenya
IPI  Intestinal parasitic infections
KM   Kilometre
Mg   Milligrams
NCAPD National Co-ordinating Agency for Population and Development
SPSS Statistical Package for Social Sciences
STH  Soil transmitted helminths
WHO  World Health Organization
µm  Micrometers
ABSTRACT

Globally, intestinal parasitic infections (IPI) such as soil transmitted helminths (STH) and protozoa have been noted as one of the most common causes of illnesses and diseases especially among economically disadvantaged communities. With an average prevalence rate of 50% in the developed countries and almost 95% in third world countries, it is estimated that intestinal parasites result in 450 million illnesses. Although IPIs are known to cause retardation in growth, diarrhoea or even death, the prevalence in primary school-going children in Mbeere North sub-county in Embu County is not documented, though there are many cases reported in health centers in the area. The aim of this study was to establish the current prevalence of IPIs in primary school children in Mbeere North sub-county and the factors that perpetuate transmission which is necessary for implementation of suitable control programs in the study area. The study was done among primary school children from nine public schools. Three schools per administrative ward were randomly selected to represent each of the three administrative wards. Stratified sampling technique was used where each ward formed a stratum. Balloting was done to sample three schools per stratum. Systematic sampling was done to sample pupils per class using the class register where the sampling interval was calculated by dividing the class size by the proportionate sample size (N/n). A total of 414 pupils whose parents/guardians gave consent participated in the study, 46 pupils per school. Each participant provided a thumb size of early morning stool. The stool samples were processed by Formal-ether concentration technique and direct wet preparation method for microscopic identification of intestinal parasites namely *E. histolytica*, *G. lamblia*, *Trichuris trichiura*, *A. lumbricoides*, and hookworm species. A structured questionnaire was used to collect data on age, sex, ward, sanitation and hygiene practices. The overall point prevalence of intestinal parasitic infections amongst the pupils was 43 %. Chi-square ($\chi^2$) test was done to determine the relationship between prevalence and the pupils’ age and sex. There was no significant association between prevalence and sex ($\chi^2 = 0.184, P = 0.668, df = 1$) but a significant association was found between prevalence and age where children 11 years and below were more pre-disposed than those above 11 years old ($\chi^2 = 4.770, P = 0.043, df = 1$). Similarly, a significant association was found between water source and prevalence of IPI; the parasites infection prevalence decreased when tap water is used and increases when open surface water is used ($F = 6.15, P = 0.006$). However, there was no significant association noted between prevalence and ward of pupil residence ($F = 1.644, P = 0.200$).

From this study there is clear indication that IPIs particularly *E. histolytica* are a problem in schools in Mbeere North. There is urgent need for provision of safe domestic water in Mbeere North Sub-county and to broaden the Mbeere water and sanitation piped water project to reach all the homesteads. Additionally, community education on sanitation and IPI transmission risk factors is urgently required. The data collected is beneficial to the public health service in designing control strategies for areas of high transmission.
CHAPTER ONE

INTRODUCTION

1.1 Background information

Intestinal parasites are mainly protozoa or helminths inhabiting the gastrointestinal tract (GIT). Generally, these intestinal parasites are more prevalent in the tropics and subtropics than any other part of the world. The four major species of intestinal helminthic parasites, also known as geohelmints / soil-transmitted helminths (STH) are Trichiuriis trichiura (whipworm), Ascaris lumbricoides (roundworm), Ancylostoma duodenale and Necator americanicus (hookworms) (Diaz et al., 2013).

About one billion people in the world are suffering from A. lumbricoides infection (CDC, 2016). While infection occurs worldwide, ascariasis is highly prevalent in sub-Saharan Africa, South America, East Asia and China (Dold et al., 2011). The eggs of A. lumbricoides are very resistant to desiccation, strong chemicals and low temperatures. The eggs stay infective in the soil for several months or even many years (Roberts et al., 2011). Ascaris lumbricoides eggs have been found in archeological coprolites in Africa, North and South America, the Middle East, Europe and New Zealand (Dridelle et al., 2010).

World Health organization (WHO) estimates that hookworms and T. trichiura infect 740 million people and 795 million people respectively (de Silva et al., 2003). Whipworm commonly occurs as a co-infection in people infected with Ascaris lumbricoides, hookworms, Entamoeba histolytica and Giardia lamblia (Klaver et al., 2013). Intestinal helminths are rarely fatal. The infection is related less to death than to the harmful gradual
effects on the nutritional status and health of the host (Stephenson et al., 2000). In addition to their negative health effects, helminthiasis impairs mental and physical growth and development of children, hinder academic performance and thwart economic achievement (Ngui et al., 2011).

The most prevalent intestinal protozoan parasites are: *Entamoeba histolytica*, *Giardia lamblia* and *Cryptosporidium* spp. The illnesses resulting from these intestinal protozoan parasites are amoebiasis, giardiasis and cryptosporidiosis respectively, and they are characterized by diarrhoea (Davis et al., 2000). The World Health Organization (WHO) approximates that about 50 million people in the world suffer from invasive amoebic disease annually, leading to 40-100 thousand fatalities yearly (Petri et al., 2000). Giardiasis is the most predominant intestinal protozoan disease with an estimated prevalence rate ranging from 2.5 to 8.5 percent in developed countries and 21% to 33% percent in most third world countries, infecting about 200 million people in the world (Mineno and Avery, 2003).

Intestinal parasitic infections are widespread with high prevalence rate among the socio-economically disadvantaged communities where poor environmental sanitation, overcrowding, lack of access to safe / clean water and low level of education are prevalent (Mehraj et al., 2008), resulting in perpetual cycle of destitution (Hotez, 2009). Soil transmitted helminths have been continuously identified as a common public health problem and most predominant of IPIs due to continuous contact with soil in daily activities (Bethony et al., 2006). Infections caused by hookworm (*Necator americanus* and
Ancylostoma duodenale), Ascaris lumbricoides and Trichuris trichiura and are most predominant among the world's poorest people (Liese et al., 2010).

Within this context, this study has provided comprehensive data on the current prevalence of IPIs among primary school children in Mbeere North Sub County in Embu County. The data / information is helpful for the public health facilities as it will assist in designing control strategies in the study area and other areas of high transmission. The goal is to lower morbidity from IPIs to a level that the infections will no longer be of public health importance.

1.2 Problem statement

There are many cases of IPI reported in health facilities in Mbeere North sub-county, hence there was need to provide exhaustive data on the current prevalence and distribution of intestinal parasitic infections among primary school pupils in the three administrative wards of Mbeere North Sub-County in Embu County. Studies have revealed that primary school children are the age group predominantly infected with intestinal parasites. These parasites have a negative effect on the socio-economic and public health of the world's economically disadvantaged people particularly children in rural and remote areas (Ngui et al., 2011). Most intestinal parasitic infections such as amoebiasis and helminthiasis are transmitted through soil and faecal contamination of water. Some studies have indicated that low education level, lack of pit latrines / toilets, low socio-economic status, poor human excreta disposal and sanitation in households are associated with parasitoses. Mbeere North sub-county is a sparsely populated area with shortage of clean water. Many
school going children are frequently absent from school due to sickness characterized by diarrhea. This study aimed at establishing the prevalence of IPIs in Mbeere North sub-county and the factors that perpetuate its transmission in order to inform development of suitable control programs in the study area.

1.3 Justification

Although IPIs are known to cause retardation in growth, anaemia, low cognitive ability and diarrhoea which leads to pupils’ absence in schools and low academic performance or even death, the prevalence in primary school-going children in Mbeere North sub county, Embu County is not documented. It was necessary to establish the factors that influence transmission of IPI in the study area which informs proper designing of effective community based control strategies. This study has provided baseline information on the prevalence of common intestinal protozoa and helminthes that can be used for development of IPIs control programs in Mbeere North Sub County and which could be extended for Embu County and other rural areas in Kenya. The overall goal of such control programs is to lower morbidity from IPIs to levels that these infections will no longer be of public health importance.

1.4 Research questions

(i) What is the point prevalence of IPI in school-going children in Mbeere North sub-county in Embu County, Kenya?

(ii) What is the distribution of IPI in the three administrative wards of Mbeere North Sub-county?
(iii) What factors contribute to the transmission of intestinal parasites in Mbeere North sub-county?

1.5 Null hypotheses

(i) Intestinal parasitic infections are not prevalent in school going children in Mbeere North sub-county in Embu County, Kenya.

(ii) The distribution of IPI in the three administrative wards varies from one ward to another.

(iii) The transmission of IPI in Mbeere North sub-county is not attributed to socio-economic, level of education and environmental factors.

1.6 Objectives

1.6.1 General objective

To determine the point prevalence and transmission risk factors of intestinal parasitic infections in school-going children in Mbeere North sub-county in Embu County, Kenya.

1.6.2 Specific objectives

(i) To determine the point prevalence of IPI, that is, *E. histolytica*, *G. lamblia*, *A. lumbricoides*, *T. trichiura* and hookworms in school children in Mbeere North sub-county in Embu County, Kenya.

(ii) To determine the distribution of IPI in the three administrative wards of Mbeere North sub-county.
(iii) To determine the factors that contribute to the transmission of intestinal parasites in school children in Mbeere North sub-county.

1.7 Significance of the study

The study has provided point prevalence of intestinal parasitic infections among primary school children in Mbeere North Sub-County, Embu County in May 2017 to July 2017. The study has also provided comprehensive data on factors highly associated with transmission of IPI in the study area. The findings of this study will be beneficial to the public health service providers and other stake holders in designing control strategies in the study area and other areas of high transmission.

1.8 Limitation of the study

This school based study did not capture children absent on the day of the survey, and some of them could have been absent due to illness, including IPIs. Due to logistical constraints, no effort was made to follow up absent children, thus introducing potential selection bias. The survey excluded school children below 8 years and those below class 3 despite the fact that younger children could probably have more risk of infection. Use of formol ether concentration technique and direct wet mount technique in IPI detection during the study probably resulted in underestimating helminths rates especially where pupils had low parasite load. A more sensitive and quantitative method such as Kato-Katz could be used in surveys in the study area to determine intensity of infection.
2.1 Overview on intestinal parasites

Intestinal parasites are the main cause of human illness in tropical countries (WHO, 2010). They can cause harm or make their host sick via an infection. Intestinal parasitic illnesses have a worldwide distribution. High levels of human infection are found in India, Africa, Central and South America (Botelho et al., 2011). The infection rate by intestinal parasites varies among countries, sanitary conditions, socio-economic status and populations as documented by Al-Harthi and Jamjoon (2007). The infections are highly endemic among the poor and socio-economically disadvantaged people living in the tropics and subtropics (WHO, 2010).

Increased cases of infections with intestinal parasites are being reported globally due to co-infection with HIV/AIDS (Lacasse et al., 2009). In the tropics and subtropics the most common intestinal protozoan parasites are *Entamoeba histolytica* and *Giardia lamblia* while the most predominant helminths are hookworms, *Ascaris lumbricoides* and *Trichuris trichiura* (WHO, 2010).

2.2 Hookworms

Hookworm disease is a soil-borne helminthiasis, categorized as a neglected tropical disease (Hotez et al., 2005). High infections occur across all ages though they are rare in adults. Hookworm rarely causes death (CDC, 2011). According to Global Burden of Disease, about 428 million people were infected with hookworms in 2015 (GBD, 2015).
The two hookworm species that predominantly infect humans are *Ancylostoma duodenale* and *Necator americanus*. *Ancylostoma duodenale* adult worms are grayish white or pink with the head slightly bent. The bend forms a hook like structure at the anterior end after which they are named. They have well-formed mouth parts with two pairs of teeth. Males measure about 1 centimeter by 0.5 millimeters while the females are longer and stouter. Moreover, males are differentiated from females by the presence of a protuberant posterior copulatory bursa (CDC, 2013).

*Necator americanus* has very many morphological similarities with *A. duodenale*, however, *N. americanus* is usually smaller than *A. duodenale* with females measuring approximately 1 cm long and males measuring about 5 to 9 millimeters. *Ancylostoma duodenale* possesses two pairs of teeth whereas *N. americanus* has a pair of cutting plates in the buccal capsule. Moreover, the hook in *Necator* is more conspicuous than in *Ancylostoma* (figure 2.1) (CDC, 2013). The eggs are elliptical or oval shaped, colorless, measuring approximately 60 µm by 40 µm and possess a thin transparent hyaline shell membrane (Appendix IV). Eggs produced by adult worms in the gut contain an unsegmented ovum. The ovum develops as the eggs pass down the intestine, resulting in eggs with segmented ovum in feces. The eggs have 4 to 8 blastomeres (CDC, 2013).
Infection of the host is by the larvae and not the eggs. The larvae, found in soil, penetrate the foot skin and once in the body, they move via the bloodstream to the lungs, then they move up to the trachea, and are swallowed. They then go down the esophagus and enter the gut, completing their migration in the small intestine where the larvae develop into adult worms (CDC, 2008). The whole journey from the time larvae penetrate skin to development of adult worms takes approximately 5 to 9 weeks. The female mature worms produce eggs (A. duodenale 25,000–30,000 eggs/day and N. americanus about 9,000–10,000 eggs per day) which are released to the environment through host’s stool. Once the eggs are in the soil, larvae hatch within many days and the life cycle starts again (Hotez et al., 2005) (Figure 2.2).
Ground-itch (allergic reaction at the point of hookworm penetration) is common in people with *N. americanus* infection. Furthermore, pneumonitis and cough may occur as the larval forms start to pierce into the alveoli and migrate up the trachea. As the larvae begin to mature in the small intestine of the host, the infected person develops gastrointestinal discomfort such as diarrhoea (Markell *et al.*, 2006). Main morbidity linked with hookworm infection results from protein malnutrition, intestinal loss of blood and iron deficiency anemia which result from ingestion of blood in the small intestines by adult hookworms, eventually degrading host’s hemoglobin. The prolonged loss of blood can become evident.
physically through peripheral and facial edema. Pica and eosinophilia resulting from iron deficiency anemia may also occur in hookworm infected people (Hotez et al., 2010).

Hookworms are blood-thirsty worms in the nematode world (Pearson et al., 2010). Midzi et al. (2010) estimated that a single *A. duodenale* takes in approximately 150 µL blood per day while *N. americanus* ingest approximately 30 µL. In cases where the worm burden is significantly high, infection is normally severe with iron deficiency anaemia, particularly in people with inadequate iron reserves or intake. Anaemia in pregnancy has been associated with hookworm infestation, especially in developing countries (Hotez, 2009). Chronic hookworm infection in children has been associated with intellectual and cognitive impairments as well as growth retardation (Hotez et al., 2005).

*Ancylostoma* and *Necator* eggs are indistinguishable, and therefore to establish the genus, the eggs are cultured in the laboratory for the larvae to hatch. When a stool sample stays for more than a day in tropical conditions, the larvae hatches and eggs may not be seen. In that case, it is important to distinguish hookworms from *Strongyloides* larvae, because infection with the latter is more virulent and requires different treatment. Hookworm rhabditiform larvae have elongated buccal cavities whereas *Strongyloides* rhabditiform larvae have short buccal cavities (Figure 2.3). *Ancylostoma* and *Necator* larvae are also differentiated microscopically although this is done mainly during research studies. Mature worms are hardly seen (except via surgery, endoscopy or autopsy), but when observed, one can easily identify the species based on length and conspicuity of the hook (CDC, 2013) (Markell et al., 2006).
The common treatment of hookworm infection is benzimidazoles (BZA), particularly mebendazole and albendazole which kill adult worms (Bethony et al., 2006). In certain circumstances such as during pregnancy, pyrantel pamoate and levamisole can be used (Hotez et al., 2005). The World Health Organization recommends antihelminthic treatment in expectant women after the first trimester (Bethony et al., 2006). In anaemia cases, iron supplements can be administered to relief problems associated with iron deficiency (CDC, 2013).

Wearing shoes is preventive, especially in places where hookworm infections are predominant. At a community level, mass deworming, reducing outdoor defecation and not using human excreta as manure is effective (CDC, 2013).
2.3 Ascaris lumbricoides

*Ascaris lumbricoides* is the "giant roundworm" of human beings, which grows up to 35 cm long. It is one of many species of *Ascaris* belonging to phylum Nematoda, and is the most prevalent parasitic helminth in humans. It causes ascariasis which is a type of helminthiasis. Helminthiases are some of the neglected tropical illnesses. Approximately 17% of people in the world are infected by *A. lumbricoides* or another roundworm (Harhay *et al.*, 2010). Ascariasis is common worldwide, mainly in tropical and sub-tropical countries (CDC, 2016).

*Ascaris lumbricoides* is a large worm, the male worm measuring between 2 and 4 millimeters in diameter and 15 to 31 centimeters long and bears a ventrally curved posterior end. Females range between 20 to 49 centimeters in length and 3 to 6 mm wide. They have an anteriorly located vulva that accounts for approximately thirty percent of the body length (Figure 2.4). The uteri have approximately 27 million eggs at a time, laying about 200,000 eggs per day. Fertilized eggs are round to oval shaped, measuring between 44 - 74 micrometers long and 30 - 45 micrometers wide with a thick shell while unfertilized eggs are approximately 87 – 93 micrometers long and 43 micrometers wide (Roberts *et al.*, 2009).
Adult *A. lumbricoides* worms inhabit the small intestine lumen where the female worms lay eggs which are passed with the faeces. The larva develops in the egg in the external environment, and hatch once the egg is ingested by a host. Viable eggs become infective after about 19 days to many weeks, subject to the conditions of the environment (optimum: warm, shaded soil, moist soil) (Ziegelbauer *et al.*, 2012). Ingested unfertilized eggs are not infective. Infection occurs by drinking water and / or eating food contaminated with *Ascaris* fertilized eggs. The larvae hatch in the small intestines then penetrate the wall of gut and move to the lungs through the circulatory system. In the lungs the larvae penetrate the air sacs and migrate up the trachea from where they are coughed up and swallowed. The larvae then migrate via the stomach for a second time into the small intestine where they develop to mature worms. The cycle from swallowing of fertilized eggs to eggs laying by the adult female worm takes about 2 to 3 months. The life span of adult worms is 1 to 2 years (Hagel and Giusti, 2010) (Figure 2.5).
Figure 2.5: Life cycle of *Ascaris lumbricoides* (Hagel and Giusti, 2010)

As larval stages migrate, they damage visceral organs, peritonitis, hepatomegaly or splenomegaly, and swelling of the lungs. Pulmonary symptoms may also occur as the larvae migrate and can manifest as Loeffler's syndrome, an illness characterized by blood eosinophilia and pulmonary infiltrates with radiographic shadowing (Torok, 2009). A worm bolus may block the intestine resulting in constipation. Worms may obstruct the ampulla of Vater, or enter the pancreatic tubule, leading to acute pancreatitis with high serum levels of lipase and amylase. Sometimes, worms migrate via the biliary system to the gallbladder, resulting in acute cholecystitis or acute cholangitis (Dold and Holland, 2011). The worms in the small intestine lumen can cause malabsorption and anorexia,
resulting in malnutrition. Malabsorption results from erosion and flattening of the villi and swelling of the lamina propria. Ascariasis may result in allergies (Berman and Jules, 2012).

Infections are asymptomatic in more than 85% of cases, particularly in people with low worm burden. The severity of symptoms depends on the worm burden and may include breathing difficulty and fever at the onset of the disease, followed by diarrhea, abdominal swelling and abdominal ache (Dold and Holland, 2011). Ascariasis mostly affects children, leading to malnutrition, poor weight gain and learning problems (Hagel and Giusti, 2010). Symptoms of larval ascariasis appear approximately 4 to 15 days following infection. The symptoms are; colic and vomiting, fever, gastrointestinal discomfort, pneumonitis, eosinophilia and identification of live worms in feces. Some people may experience neurological disorders or pulmonary symptoms during larval migration. Bowel obstruction may occur (Ziegelbauer et al., 2012).

World Health organization recommends albendazole; levamisole, mebendazole or pyrantel pamoate for treatment of ascariasis. Pyrantel pamoate is contraindicated for people with heavy worm burden because it can induce intestinal obstruction. Albendazole is not recommended for pregnant women and infants less than two years old (Hagel and Giusti, 2010).

Proper sanitation which comprises of improved access and use of toilets / latrines and proper faecal disposal is one of the most effective preventive measures (Ziegelbauer et al., 2012). Handwashing with soap is protective (Fun and Cairncross, 2009). Effective fecal
treatment systems and educated hygienic habits / culture are required for prevention of any fecal borne disease. This is significant with *A. lumbricoides* eggs since they are very difficult to kill, and the eggs can survive 1 – 3 years. *Ascaris lumbricoides* eggs are resistant to bleach; however, it removes their sticky film, allowing easy rinsing of the eggs. The eggs can be made uninfective by hot composting method, however, to sterilise them requires rubbing iodine, alcohol, special chemicals, cooking heat or "unusually" hot composting at over 50 °C (122 °F) for about 24 hours (Blackwell *et al.*, 2015). In a community where over 20% of the people are infected, regular mass treatment is recommended (Dold and Holland, 2011).

2.4 *Trichuris trichiura*

The human whipworm (*Trichuris trichiura* or *Trichocephalus trichuris*) is a round worm causing trichuriasis when it infects human large intestine. The name whipworm is derived from the worm’s body shape; whip like shape with wider "handles" at the posterior end (Hayes *et al.*, 2010). *Trichuris trichiura* is characterized by its slender anterior esophageal side and broad and shorter posterior anus. The worms appear pinkish white and have threads throughout the mucosa. They anchor to the host by their narrow anterior end and dissolve tissues into digestible secretions which they feed on instead of blood. Generally, females are bigger than males; measuring about 34 to 50 millimeters long compared to 31 – 46 millimeters for males. The female worms have a blunt rounded posterior end while the males have a coiled posterior end (Figure 2.5). Their distinctive eggs are brown barrel shaped and possess bipolar protuberances (Klaver *et al.*, 2013) (Figure 2.6).
Female *T. trichiura* releases approximately 3,000 –11,000 unicelled eggs in a day. The eggs deposited from human feces to soil embryonate after 2 to 3 weeks and enter the “infective” stage. The embryonated eggs are ingested and larvae hatch in the small intestine, using the intestinal microflora as stimulus for hatching. It is in the small intestine where growth and molting take place. The infective larvae penetrate the villi of the small intestine for further development. The immature worms migrate to the caecum and enter the mucosa, completing their development to mature worms in the large intestine. The lifecycle from the moment eggs are ingested to development of adults takes about twelve months. During this time, there are very few signs of infection in stool specimen since there are no eggs produced and shed. The female *T. trichiura* start laying eggs after twelve weeks of maturity (Hayes et al., 2010) (Figure 2.7).
Trichuriasis occurs via ingestion of eggs and is predominant in warm regions due to favorable conditions of warmth and moisture, hence its tropical distribution. The whipworm eggs are released in the stool of infected individuals and when an infected individual defecates outside or if untreated human stool is used as manure, eggs are released on soil from where they develop to an infective form. Ingestion of the eggs occur when fingers or hands soiled with dirt are inserted in the mouth, through consumption of improperly cooked vegetables or intake of fruits that have not been properly peeled or washed (Klaver et al., 2013).
2.5 Entamoeba histolytica

*Entamoeba histolytica* is an anaerobic parasitic protozoa belonging to the genus *Entamoeba* and commonly infects human beings and other primates resulting in amoebiasis. It is estimated that *E. histolytica* infects approximately 50 million people worldwide. *E. histolytica* is predominant in people living in tropical regions with deplorable sanitary conditions, institutionalized populations, travelers, male homosexuals and recent immigrants. Mammals like cats and dogs can get infected transiently, though they are not significantly associated to transmission in humans (Nespola et al., 2015).

*Entamoeba histolytica* has an amoeboid body form and possesses pseudopodia for movement and food procurement. It has cyst and trophozoite stages in its life cycle. Cysts are the infective form. They are spherical with approximately 10 to 16 μm diameter and have 1 to 4 nuclei. When mature, they have four nuclei (CDC, 2015) (Figure 2.8). There is an energy reserve (glycogen) in a distinct vacuole inside the immature cyst becoming diffuse at mature cysts, whose cell wall is composed of chitin (Botelho et al., 2011). Trophozoites are the vegetative forms and are associated with pathology. They usually measure 20 to 40 μm, but are likely to reach 60 μm in the most invasive forms. Trophozoites have a single nucleus which is very distinguishable when stained but rather clear in fresh preparations. In fresh preparations, trophozoites are pleomorphic and rapidly produce thick and hyaline pseudopodis which seem to slip over the blade’s surface (Silva and Gomes, 2005).
Figure 2.8: Cyst and trophozoite stages of *E. histolytica* (Silva and Gomes, 2005)

The life cycle consists of the active (trophozoite) stage which survives only in the host and in fresh loose stool. Cysts exist outside the host in soils, water and on foods. When cysts are ingested, they cause infections by excysting (releasing the trophozoites) in the gut (Figure 2.9).
On excysting, the trophozoites settle in the large intestine, colonizing the lining of the mucoid layer and ingesting food particles and bacteria (Nespola et al., 2015). Occasionally, trophozoites may migrate through the mucoid layer and get in contact with the epithelium layer where they begin the pathological activity. *Entamoeba histolytica* possess a lectin that attach to galactose and N-acetylgalactosamine sugars on the epithelial cells’ lining. The lectin is usually used for binding bacteria for feeding. *E. histolytica* parasites have
numerous enzymes such as lipases, pore boring proteins and cysteine proteases, which are used in digesting bacteria in food vacuoles but can cause destruction of the epithelium layer, resulting in cellular necrosis and apoptosis when the trophozoites get in contact with it and binds via the lectin. The epithelial dead cells are then ingested by trophozoites (Lorenzi et al., 2010). The destruction of cells of the epithelium triggers body immune cells which in turn can be destroyed by the trophozoites, by releasing the immune cell's own lytic enzymes to the adjacent tissues, leading to a kind of chain reaction and resulting in tissue destruction. The tissue damage is manifested in form of flask shaped 'ulcers' in the tissue, described so due to their appearance in transverse section (Kelso et al., 2015).

Blood vessels can also be damaged resulting in bloody diarrhea, amebic dysentery. When trophozoites penetrate the circulatory system, they migrate to the liver through the portal blood vessels. On reaching the liver a similar pathology occurs, resulting in amebic liver abscesses. The trophozoites can also find their way into other organs through the bloodstream or via bursting of liver abscess. In all sites, a similar pathological process can ensue (Singh et al., 2013).

*Entamoeba histolytica* infection can be asymptomatic or can result in amebic dysentery or amebic liver abscess (Nespola et al., 2015). Symptoms of amoebiasis are fulminating dysentery, weight loss, bloody diarrhea, abdominal pain, fatigue and amoeboma (Hung et al., 2005). Amoeba can be diagnosed using stool samples. Trophozoites may be seen in a fresh stool smear and cysts in an ordinary stool sample. ELISA or RIA can also be used to detect amoebiasis antibodies in serum (Hung et al., 2005).
Intestinal amoebiasis is treated using nitroimidazole derivatives because they are highly effective against the trophozoites. These drugs are accompanied by other drugs such as diloxanide furoate or paromomycin since nitroimidazole derivatives have little effect on amoeba cysts (Kucik et al., 2004). Besides targeting *E. histolytica* in solid tissues with drugs such as metronidazole and chloroquine, treatment of liver abscess also involves drugs that act in the intestine’s lumen to avoid re-invasion (Kucik *et al.*, 2004).

### 2.6 Giardia lamblia

*Giardia lamblia*, also called *Giardia intestinalis*, is a flagellated endoparasite that invades and multiplies in the small intestine, resulting in giardiasis. If the organism is split and stained, its salient shape resembles the familiar "smiley face" symbol (Figure 2.10). *Giardia* infects humans, though it is also one of the most predominant intestinal parasites in cats, dogs and birds (Tzanidakis *et al.*, 2014). Mammalian hosts also include dozens of other animals such as cows, beavers, deer and sheep (Heyworth and Martin, 2016). Giardiasis does not spread to other body parts but remains localised in the lumen of the small intestine. Trophozoites obtain nourishment from the lumen of the small intestine and respire anaerobically (Hogan and Michael, 2010).
Giardiasis can result from ingestion of *Giardia* cysts in contaminated food, water or by the fecal-orl route (through improper hygiene practices). The cysts survive for several days to months in cold water hence can be found in polluted wells and water systems, particularly stagnant water sources, like naturally occurring ponds, water storage tanks and even clean-looking highland streams. The cysts can also be present in water reservoirs and persist after water treatment because of their resistance to ordinary water sterilization methods such as chlorination and ozonolysis. Zoonotic transmission is also feasible hence giardiasis is a concern for people camping in the wilderness or swimming in polluted streams or lakes (Huang and White, 2006).

Besides waterborne sources, fecal–oral transmission can take place in day care centers where children may be exposed to improper hygiene practices. Those working with children are also predisposed to infection as are family members of infected persons. Some
*Giardia* attacks are asymptomatic hence several infected persons unknowingly serve as carriers of the parasite (Tzanidakis *et al.*, 2014).

The lifecycle starts when noninfective cysts are released with the stool of an infected person. *Giardia* cysts are hardy, ensuring protection from a wide range of heat, cold and dehydration. Once swallowed by a suitable host, trophozoites develop to an active stage of feeding and motility after which they undergo asexual reproduction by longitudinal binary fission. The resulting trophozoites and cysts move via the gut into the environment through stool. Only the cysts are hardy enough to survive outside the host (Huang and White, 2006) (Figure 2.11).
Figure 2.11: Life cycle of *Giardia lamblia* (Huang and White, 2006)

Symptoms of giardiasis are (in order of frequency) diarrhea, malaise, flatulence, steatorrhoea (pale, foul smelling, greasy stools), epigastric pain, bloating, nausea, reduced appetite, possible (but rare) vomiting which is often violent and weight loss. In healthy persons, the infection is normally self-limiting but it can be prolonged in immunocompromised individuals or those with low gastric acid secretion (Huang and White, 2006).
Infection in human is ordinarily treated with metronidazole, tinidazole or nitazoxanide. Metronidazole is the current first-line therapy; however, it’s mutagenic in bacteria and carcinogenic in mice hence not recommended during pregnancy (Huang and White, 2006). Boiling water for at least a minute is the best method of ensuring water is safe for drinking and kills disease-causing microorganisms such as *Giardia lamblia* (Emergency Disinfection of Drinking Water, 2013). Chemical disinfectants may also be used to kill the trophozoites (Betancourt and Rose, 2004).

### 2.7 Risk factors for transmission of IPI

Environmental, socio-economic, demographic, low education level and hygiene related behavior influence the transmission and distribution of intestinal parasitic infections (Norhayati *et al*., 2003). A study done in Brazil associated place of residence, age, intake of raw / poorly cooked vegetables and quality of drinking water as major risk factors (Benetton *et al*., 2005). Prevalence of IPI is more related to poor environmental sanitation and personal hygiene than to climate. Socio-economic factors as well as unpredictable factors such as food insecurity, droughts, and floods contribute to the problem (WHO, 2011). Unavailability of safe domestic water and low education on sanitation also contribute to transmission (AMREF, 2009). Most intestinal parasites gain entry into the intestines through the mouth from undercooked food, vegetables, or contaminated water or hands, hookworm larvae penetrate skin. Poor personal hygiene, poor garbage disposal and poor disposal of human excreta are significant for this oral-faecal infection (Blessman *et al*., 2002). Infective eggs may contaminate vegetables when untreated human stool of infected individuals is used as fertilizer for food crops. Infection may also take place when
food is handled without killing or removing the infective eggs on hands, clothes, hair, raw vegetables / fruit, or cooked food that is (re)infected by handlers, containers, etc (Blackwell et al., 2015).

Transmission may also be through mechanical vectors such as flies whereby flies may carry the infective cysts or eggs from contaminated sites or dirty latrines and cause contamination of food and / or water (Nyarango et al., 2008). Many tropical developing countries lack adequate supply of clean domestic water. Contamination may occur at the source of water or at home due to poor sanitation (UNICEF, 2009). Another risk factor is the availability and usage of toilets. When people defecate in the open, cysts can be washed down to water bodies or may be carried by mechanical vectors such as flies and contaminate food or water sources (Cheesebrough, 2005).

### 2.8 Control of intestinal parasites

Improvement of sanitation, clean / safe water supply, food hygiene and health education coupled with treatment of infected individuals reduces intestinal parasites’ transmission in the long term (Ngonjo et al., 2012). An analytical review of health progress and systems performance, 1994 – 2010 by the ministry of public health of Kenya reports that improved sanitation which includes provision of safe domestic water, availability of improved pit latrines and flush toilets and regular hand washing contributes greatly in reduction of diarrhoeal diseases. In a study to establish the prevalence of waterborne protozoan parasites in western Cameroon (Richardson et al., 2012), it was observed that due to improved
sanitation in Bawa village, infections with intestinal parasites were lower at 7.1% compared to Nloh village (15.7%) which had unimproved sanitation.

Health education creates awareness on personal hygiene and healthy behavior to reduce transmission of intestinal parasites and re-infection. Communities need to be educated on proper latrines/toilets use, regular washing hands, protection of water supplies from faecal contamination, proper cooking and handling of food (Cheesebrough, 2005). Richardson et al., (2012) reported that with enhanced education programmes on sanitation and hygiene such as conferences and seminars, 84% reduction in water borne diarrhoeal diseases was realized in Bawa village in western Cameroon.

One can contract IPI by eating food or drinking water contaminated with intestinal parasites’ cysts or trophozoites. Food related practices that may contaminate food with intestinal parasites are; Improper cooking where the food is halfway cooked, failure to wash hands thoroughly with soap and warm running water for about 10 seconds after using toilet or changing a baby's diaper and before handling food, eating raw vegetables and eating street foods especially in public places (DPHS, 2010). Water source/supply is a significant risk factor for intestinal parasites and several large outbreaks of IPI have resulted from contamination of municipal water supplies with human excreta (Ngonjo et al., 2012).
2.9 Knowledge gap

Although IPIs cause retardation in growth, diarrhoea or even death, the prevalence in primary school-going children in Mbeere North sub-county in Embu County is not documented, yet there are several cases reported in health centers in the area. This study has established the current prevalence of IPIs in primary school children in Mbeere North sub-county and the factors that perpetuate transmission which is necessary for implementation of suitable control programs in the study area and other areas of high transmission.
CHAPTER THREE
MATERIALS AND METHODS

3.1 Study site

The study was done in Mbeere North sub-county within Embu County in Kenya. Embu County is approximately 160 KM east of Nairobi, the country’s capital, at the foot of Mt. Kenya. The main town in Mbeere North is Siakago. According to 2009 population census, Mbeere North sub county had a population of 103,483 and an area of 1,046 km² (Republic of Kenya, 2009). The sub county borders Embu East, Tharaka, Mwingi and Mbeere South sub counties to the Northwest, North, East and South respectively. Mbeere North sub-county has three administrative wards; Evurore, Nthawa and Muminji. The altitude ranges from approximately 500m above sea level on the Tana River basin to 1200m (Mwaniki, 1973), (Appendix I).

The rainfall has a bimodal pattern with the long rains falling between April and June while the short rains are experienced from October to December. The rainfall ranges between 640 mm to 1100 mm per year with most parts receiving 550 mm per year which is not reliable for agriculture. The mean annual rainfall is 765 mm of which 60 % (442 mm) falls between April and June and 40 % (323 mm) falls between October and December (Okoba et al., 1997). Most Mbeere soils are sandy and clay, few areas have loam soil. The average annual temperature in Mbeere North is 24.9 degrees Celsius and humidity is low with average evaporation of 2020 mm, exceeding annual precipitation of 765 mm (Mwaniki, 1973). The dominant crops include fruits such as mangoes, water melons, paw paws, passion fruits, maize, beans, cowpeas, pigeon peas, millet and black peas - njavi. Miraa is
a major cash crop in some areas. The area is served by two public hospitals namely; Siakago District Hospital and Ishiara Sub-District Hospital. There are a few private clinics but their services are not readily available to most villagers because of prohibitive cost. The residents get water from canals, piped water, Ena River, dry riverbeds, seasonal streams and open wells.

3.2 Study design

The research design was a cross-sectional descriptive study involving one time sampling of public primary school children. It involved nine public primary schools - three schools in each of the three administrative wards constituting Mbeere North Sub-County. The schools were: Siakago, Riandu and Maathai in Nthawa ward, Kivue, Gangara and Karambare in Muminji ward, Gwakaithi, Kieniri and Ngunyumu in Evurore ward.

3.3 Study population

The study population was primary school children from nine randomly selected public primary schools in Mbeere North Sub-county. Each of the three wards formed a stratum where balloting was done to select three schools per ward. All the children aged 8-15 years of both sexes and in class 3 to 8 were targeted in the study since they were able to fill questionnaire with guidance. A list of enrolled pupils in class 3 to 8 was obtained from the headteacher in each school and age of child confirmed from the parent when obtaining the informed consent.
3.4 Inclusion criteria

All children aged 8-15 years and in class 3 to 8 from the selected schools whose parents gave consent to the study were included in study.

3.5 Exclusion criteria

All children aged 8-15 years whose parents did not consent to the study, those outside age 8-15 years and all those below class three were excluded from the study.

3.6 Sampling technique

Stratified sampling technique was used where each ward formed a stratum. Balloting was done to select three schools per stratum. Systematic sampling was done to sample students per class using the class register where the n\text{th} individual after the starting point was selected. The sampling interval was calculated by dividing the class population size by the sample size (N/n).

3.6.1 Sample size determination

Sample size was determined by use of the following formula:

\[ n = \frac{Z^2pq}{d^2} \]  \quad \text{(Mugenda and Mugenda, 2003)}.

Where \( p \) = estimated prevalence of intestinal parasitic infections in the study area.

\( 0.5 \) because IPI prevalence in Mbeere North is not known.

\( q = 1-p, \quad d = \text{level of statistical significance (0.05)} \)

\( Z = \text{standard normal deviation which corresponds to 95}\% \text{ confidence interval (1.96)} \)
\[ n = 1.96^2 \times 0.5 \times 0.5 = 385 \text{ pupils.} \]

Therefore the sample size was raised to 414 pupils to cater for eventualities such as failure to sign informed consent form and data loss.

Number of pupils per school was \( \frac{414}{9} = 46 \).

Number of pupils per class = 8

### 3.7 Data collection

Data on transmission risk factors was collected using a structured questionnaire administered to the selected pupils while data on IPI was obtained by microscopically analyzing stool samples provided by the study participants.

### 3.7.1 Collection of data on food and personal hygiene, sanitation and education level

Before the study begun, an oral briefing explaining the objectives of the study was given to the participants and their parents / guardians and a voluntary signed consent obtained from each participant’s parent / guardian. The participants (pupils) were then asked by the researcher to fill a questionnaire designed to collect demographic data (age, sex and ward of residence), practices on personal hygiene, parents’ education level, water handling and consumption habits and to assess latrine availability and utilization (Appendix VII). Pupils were advised to inquire about parents’ education level from the parent. The respondents answered the questionnaire with the help of their class teachers in the presence of the researcher.
3.7.2 Stool collection

Participants were registered the day before stool specimen collection in each school. Each participant was given a clean, dry, leak-proof, well labeled (with the participant’s code) specimen container and instructed, through the class teacher to scoop a thumb size (approximately 5g) of early morning stool sample using a provided scoop into the container, ensuring the sample was not contaminated with urine. The stool specimens were collected the first thing in the morning before the beginning of lessons by the researcher and a laboratory technician and transported immediately to Mbeere District Hospital laboratory for processing and microscopic examination. Examination was carried out by the researcher assisted by qualified laboratory technologists within the same day of collection of the specimen to avoid degradation.

3.7.3 Processing of fecal samples and analysis

The stool specimens were processed using formol ether concentration technique (Appendix II) and direct wet mounts (Appendix III) to examine for eggs of helminths and cysts and oocysts of protozoan parasites. Hookworm eggs were identified based on their elliptical / oval shape and presence of a thin transparent hyaline shell membrane. *A. lumbricoides* adults were characteristically long with a ventrally curved posterior end while the eggs were oval to round shaped with a thick shell. *T. trichiura* eggs appeared barrel shaped with distinctive bipolar protuberances. *E. histolytica* trophozoites were pleomorphic, possessed pseudopodia and a single nucleus which was very distinguishable when stained. The cysts were spherical with 1 – 4 nuclei. *G. lamblia* trophozoites’ appearance resembled the familiar “smiley face” symbol while the cysts were quadrinucleated with visible axostyles.
The protozoa and helminths were identified using identification key (Appendix IV) (WHO, 1994). The number of infected children, their age, sex and ward of residence was recorded.

3.8 Ethical consideration

Approval to carry out the study was obtained from Kenyatta University Graduate School (Appendix VIII (e), National Commission for Science, Technology and Innovation (Appendix VIII (c), Ministry of Interior and Coordination of National Government (Appendix VIII (d), Ministry of Health – Embu County (Appendix VIII (a). Ethical clearance was obtained from Kenyatta University Ethical Review Committee (Appendix VIII (f) after receiving a research authorization letter from the Graduate School (Appendix VIII (b). Informed signed consent was obtained from parent / guardian of each child (Appendix VI). Confidentiality was maintained and all the children whose stools contained intestinal parasites were referred to hospital for treatment.

3.9 Data analysis

Data collected on the number of infected pupils per age group, administrative ward of residence and sex, source of water and hygiene practices was entered into raw data forms before entering it into excel spreadsheet. Data analysis was carried out using SPSS version 20.0 for windows developed by IBM Corporation, United States. Percentages were used to describe the characteristics of the studied population, including the prevalence of IPIs in each administrative ward, age sets and sex. A Pearson's Chi-square ($X^2$) on proportion was used to test the associations between the dependent variable against the independent variable. The dependent variable was prevalence of IPIs, while the independent variables
were socio-demographic factors (age and sex), source of water, education level, administrative wards of residence and environmental sanitation. The level of statistical significance was $P < 0.05$. 
CHAPTER FOUR

RESULTS

4.1 Demographic characteristics of the respondents

Out of the 414 pupils that participated in the study 52.9 % were females and 47.1 % were males. The participants were divided into two age sets; those 11 years and below and those 12 years and above. Of the 414 pupils studied across the three administrative wards, 138 (33.3 %) pupils were from Nthawa ward, 137 (33.1 %) from Muminji ward and 139 (33.6 %) from Evurore ward (Table 4.1).

Table 4.1: Socio-demographic characteristics of study participants (n= 414)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Attribute</th>
<th>Number</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>Female</td>
<td>219</td>
<td>52.9</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>195</td>
<td>47.1</td>
</tr>
<tr>
<td>Age( years)</td>
<td>11 years and below</td>
<td>212</td>
<td>51.2</td>
</tr>
<tr>
<td></td>
<td>Above 11 years</td>
<td>202</td>
<td>48.8</td>
</tr>
<tr>
<td>Administrative</td>
<td>Nthawa</td>
<td>138</td>
<td>33.3</td>
</tr>
<tr>
<td>ward</td>
<td>Muminji</td>
<td>137</td>
<td>33.1</td>
</tr>
<tr>
<td></td>
<td>Evurore</td>
<td>139</td>
<td>33.6</td>
</tr>
</tbody>
</table>

4.2. Prevalence of IPI in primary school pupils in Mbeere North sub-county

The types of parasites observed in the stool specimens were A. lumbricoides, hookworms, T. trichiura, E. histolytica and G. lamblia (Figure 4.1 and 4.2). The parasites were identified using identification key for diagnosis of intestinal parasites (Appendix IV)
(WHO, 1994). Some commensals such as *Entamoeba coli, Endolimax nana* and *Iodamoeba butschlii* were also observed. The overall point prevalence of IPI in the studied pupils was 43.0% (Table 4.2). Out of the 414 pupils sampled, 178 were infected while 236 were not, as revealed through stool examination. Out of the 178 infected cases, 17.4% were infected by more than one type of parasites. Another 3% had three types of IPIs.

![Figure 4.1: Micrographs of *E. histolytica* and *G. lamblia* cysts respectively](image1)

![Figure 4.2: Micrographs of *A. lumbricoides, T. trichiura* and hookworm eggs respectively](image2)

Of the 219 female pupils, 92 (42%) were infected with intestinal parasites while 86 out of the 195 males (44.1%) were infected with intestinal parasites (Table 4.2). There was no
statistically significant association between intestinal parasitic infections and sex ($\chi^2 = 0.184, P = 0.668, df = 1$). Further analysis of infection rate based on age revealed that children 11 years and below had a 48 % prevalence which was higher than 37.6 % for children above 11 years old (Table 4.2). When Chi-square ($\chi^2$) test was done to determine the relationship between the prevalence of intestinal parasites and pupil’s age, a computed value of $\chi^2 = 4.770, P = 0.043, df = 1$ was obtained for infected cases (Table 4.2). Hence the intestinal parasites were observed to be dependent on age ($P < 0.05$).

**Table 4.2: Prevalence of IPI by sex and age of the pupils (n= 414)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Category</th>
<th>Uninfected</th>
<th>Infected / Prevalence</th>
<th>$\chi^2$</th>
<th>Df</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>Female</td>
<td>127 (58%)</td>
<td>92 (42%)</td>
<td>0.184</td>
<td>1</td>
<td>0.668</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>109 (55.95%)</td>
<td>86 (44.1%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subtotals</td>
<td></td>
<td>236</td>
<td>178</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>11 years and below</td>
<td>110 (51.9%)</td>
<td>102 (48.1%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Above 11 years</td>
<td>126 (62.4%)</td>
<td>76 (37.6%)</td>
<td>4.770</td>
<td>1</td>
<td>0.043</td>
</tr>
<tr>
<td>Subtotals</td>
<td></td>
<td>236</td>
<td>178</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall prevalence</td>
<td></td>
<td></td>
<td></td>
<td>43.0%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The overall point prevalence of IPI was 43 % and infections were dependent on age ($\chi^2 = 4.770, P = 0.043, df = 1$)
4.2.1 Prevalence of IPI by species

The overall prevalence of *Entamoeba histolytica* was 36.23 %, making it the most prevalent IPI in Mbeere North Sub-county. The overall prevalence of helminthiasis was 13 %. The least prevalent IPI was hookworms at 3.62 % (Figure 4.3).

Figure 4.3: Prevalence of IPI in Mbeere North by species

<table>
<thead>
<tr>
<th>Species</th>
<th>Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>E. histolytica</em></td>
<td>36.20%</td>
</tr>
<tr>
<td><em>G. lamblia</em></td>
<td>8.21%</td>
</tr>
<tr>
<td>Hookworms</td>
<td>3.62%</td>
</tr>
<tr>
<td><em>T. trichiura</em></td>
<td>3.86%</td>
</tr>
<tr>
<td><em>A. lumbricoides</em></td>
<td>4.35%</td>
</tr>
</tbody>
</table>

*E. histolytica* was the most prevalent intestinal parasite ($F = 4.31, P = 0.031$).

4.3 Distribution of IPI in Nthawa, Muminji and Evurore wards of Mbeere North Sub-County

Different intestinal parasites were observed in the stool specimen of the respondents across the three administrative wards. Out of the 138 sampled pupils from Nthawa, 54 (39.13 %) were infected by at least one type of intestinal parasite while Muminji and Evurore had a prevalence of 43.1 % and 46.8 % respectively. The most prevalent IPI was *Entamoeba*
*histolytica* at 35.5 % in Nthawa, 32.1 % in Muminji and 41 % in Evurore although the differences among the three wards were not statistically significant (F = 1.68, P = 0.182) (Table 4.3).

Analysis on prevalence of infections in individual wards revealed that infections were not evenly spread among the three wards studied. Pupils from Evurore ward had higher infections (46.7 %), followed by Muminji ward (43.07 %) and Nthawa ward had the least infections (39.13 %). ANOVA test done to determine the relationship between the prevalence of intestinal parasites and wards indicated that there was no statistically significant difference in infection rates among the different administrative wards where the pupils were resident (F = 1.644, P = 0.200).
Table 4.3: Distribution of intestinal parasites in the three administrative wards of Mbeere North sub-county

<table>
<thead>
<tr>
<th>Ward</th>
<th>Parasite</th>
<th>Infected Male n (%)</th>
<th>Infected Female n (%)</th>
<th>Total infected (n)</th>
<th>% Prevalence</th>
<th>F-value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nthawa</td>
<td><em>E. histolytica</em></td>
<td>27 (19.6%)</td>
<td>22 (15.9%)</td>
<td>49</td>
<td>35.5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>G. lamblia</em></td>
<td>7 (5.1%)</td>
<td>6 (4.3%)</td>
<td>13</td>
<td>9.42%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>A. lumbricoides</em></td>
<td>3 (2.2%)</td>
<td>2 (1.4%)</td>
<td>5</td>
<td>3.62%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Hookworms</em></td>
<td>2 (1.4%)</td>
<td>2 (1.4%)</td>
<td>4</td>
<td>2.9%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>T. trichiura</em></td>
<td>4 (2.9%)</td>
<td>1 (0.7%)</td>
<td>5</td>
<td>3.62%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>43 (31.2%)</td>
<td>33 (23.9%)</td>
<td>76</td>
<td>39.1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muminji</td>
<td><em>E. histolytica</em></td>
<td>24 (17.5)</td>
<td>20 (14.6)</td>
<td>44</td>
<td>32.1%</td>
<td>1.644</td>
<td>0.200</td>
</tr>
<tr>
<td></td>
<td><em>G. lamblia</em></td>
<td>5 (3.6%)</td>
<td>4 (2.9%)</td>
<td>9</td>
<td>6.57%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>A. lumbricoides</em></td>
<td>4 (2.9%)</td>
<td>5 (3.6%)</td>
<td>9</td>
<td>6.57%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Hookworms</em></td>
<td>4 (2.9%)</td>
<td>1 (0.7%)</td>
<td>5</td>
<td>3.65%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>T. trichiura</em></td>
<td>2 (1.5%)</td>
<td>4 (2.9%)</td>
<td>6</td>
<td>4.38%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>39 (28.5%)</td>
<td>34 (24.8%)</td>
<td>73</td>
<td>43.1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evurore</td>
<td><em>E. histolytica</em></td>
<td>30 (21.6)</td>
<td>27 (19.4%)</td>
<td>57</td>
<td>41%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>G. lamblia</em></td>
<td>7 (5%)</td>
<td>5 (3.6%)</td>
<td>12</td>
<td>8.63%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>A. lumbricoides</em></td>
<td>1 (0.7%)</td>
<td>3 (2.2%)</td>
<td>4</td>
<td>2.88%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Hookworms</em></td>
<td>4 (2.9%)</td>
<td>2 (1.4%)</td>
<td>6</td>
<td>4.32%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>T. trichiura</em></td>
<td>3 (2.2%)</td>
<td>2 (1.4%)</td>
<td>5</td>
<td>3.6%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>45 (32.4%)</td>
<td>39 (28.1%)</td>
<td>84</td>
<td>46.8%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Evurore had a 46.8 % prevalence of IPI, which was slightly higher than 43.1 % and 39.1 % for Muminji and Nthawa respectively, although the difference was statistically insignificant (F = 1.644, P = 0.200).

4.4 Factors that contribute to the transmission of intestinal parasites in school children in Mbeere North Sub-County

Data on prevalence of IPI in relation to the source of water indicated that children of families using ponds, earth dams, dry river bed wells, canals and rivers had the highest prevalence rates amongst the water sources at 100 %, 56 %, 48.5 %, 45 % and 39 %
respectively (Table 4.4). A statistically significant association was found between the water source and high prevalence of intestinal parasites (F = 6.15, P = 0.006).

Of the total respondents, 60 (14.5%) had their water sources protected either by fencing or covering. Of these, 33.3% were found to be infected with intestinal parasites. Of the 85.5% whose water sources were not protected 44.6% were found to be infected (Table 4.4). No significant association was observed between protection of water sources and prevalence of intestinal parasites (OR = 0.620, CI = 95%) (χ² = 2.673, df = 1, P = 0.102) (Table 4.4).

Of the 414 respondents, 68 (16.4%) had their drinking water treated / boiled in their home, out of whom 20.6% were infected. Of the remaining 83.6% who did not treat their drinking water at home, 47.4% were infected (Table 4.4). Those who did not treat or boil drinking water were significantly more infected than those who treated / boiled (OR = 0.288, CI = 95%), (χ² = 16.667, df = 1, P = 0.000).

Of the 414 respondents, 7 (1.7%) did not have any form of toilet facility in their homes, preferring to relieve themselves in the bushes while 407 (98.3%) had toilets or latrines at home. Out of the 407, 355 (85.7%) used traditional pit latrines, hence the most common facility. Of the 355, 161 (45.4%) were infected. Out of the 7 respondents who did not have any form of toilet facility at home, 5 (71.4%) were infected while out of the 407 pupils who had toilet facilities at home, 173 (42.5%) were infected. ANOVA test revealed a
significant association between the use / type of toilet facilities at home and the rate of intestinal parasites infections (F = 4.802, P = 0.029) (Table 4.4).

Eighty seven respondents (21 %) shared toilet with other households in the neighborhoods, of whom 39 (45 %) were infected with IPI while 41.9 % of those who did not share toilet facilities were infected. Chi-square test revealed that sharing or not sharing toilet facilities with neighbors did not affect IPI status ($\chi^2 = 0.689$, df = 1, P = 0.407, OR = 0.815) (Table 4.4).

Of the 407 respondents who had toilet / pit latrines at home, 268 (65.8 %) had flood water overflow in the toilets / latrines during rainy season. Chi-square test revealed a significant association between overflow of flood water in toilets and infection with intestinal parasites ($\chi^2 = 13.636$, df = 1, P = 0.000) (Table 4.4). This means that overflow of rain water in toilets led to increased prevalence of intestinal parasitic infections.

Having siblings less than 5 years old at home did not affect prevalence of intestinal parasites (OR = 1.225, CI = 95 %), ($\chi^2 = 1.040$, df = 1, P = 0.308). The two hundred and sixteen respondents who had siblings less than 5 years old gave varying responses on child waste disposal, the most common being rinsing away (66.2 %), followed by throwing the waste outside the house / dwelling (22.2 %). ANOVA test revealed a significant association between child’s waste disposal method and the prevalence of intestinal parasite infections ($F = 5.24$, $P = 0.037$) (Table 4.4). Hence throwing child waste outside the house / dwelling increased prevalence of intestinal parasitic infections.
Most respondents’ parents’ highest level of education was primary school where 247 (59.6%) had mother’s highest education level as primary education while 218 (52.7%) had their father’s highest education level also as primary school. Only 7% of the respondents had their mothers educated upto post-secondary. ANOVA test revealed that prevalence of intestinal parasites decreased in children whose parents had higher education level (F = 7.39, P = 0.002) for mother and (F = 7.92, P = 0.001) for father’s highest education level being post-secondary (Table 4.4).
Table 4.4: Risk factors contributing to transmission of intestinal parasites in Mbeere North sub-county (n=414)

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Variable</th>
<th>No. of respondents (%)</th>
<th>Odds ratio</th>
<th>$\chi^2$</th>
<th>F-Value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main water source at home</td>
<td>Bore hole</td>
<td>21 (33.3%)</td>
<td></td>
<td></td>
<td>6.15</td>
<td>0.006</td>
</tr>
<tr>
<td></td>
<td>Tap</td>
<td>39 (28.2%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spring</td>
<td>6 (33.3%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Canals</td>
<td>80 (45%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>River</td>
<td>100 (39%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Earth dam</td>
<td>25 (56%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dry riverbed wells</td>
<td>136 (48.5%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rainwater</td>
<td>4 (0%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bottled water</td>
<td>0 (0%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pond /lake</td>
<td>3 (100%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water source protected/covered</td>
<td>Yes</td>
<td>60 (33.3%)</td>
<td>0.620</td>
<td>2.673</td>
<td></td>
<td>0.102</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>354 (44.6%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water treated/boiled</td>
<td>Yes</td>
<td>68 (20.6%)</td>
<td>0.288</td>
<td>16.667</td>
<td></td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>346 (47.4%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toilet facility at home</td>
<td>Flush toilet</td>
<td>10 (20%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Traditional pit latrine</td>
<td>355 (45.4%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ventilated improved pit</td>
<td>42 (23.8%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No facility</td>
<td>7 (71.4%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sharing toilet with other households</td>
<td>Yes</td>
<td>87 (45%)</td>
<td>0.815</td>
<td>0.689</td>
<td></td>
<td>0.407</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>320 (41.9%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rain water overflow in toilets / pit latrines</td>
<td>Yes</td>
<td>261 (49.6%)</td>
<td>2.211</td>
<td>13.636</td>
<td></td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>146 (30.8%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Siblings less than 5 years</td>
<td>Yes</td>
<td>216 (45.4%)</td>
<td>1.225</td>
<td>1.040</td>
<td></td>
<td>0.308</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>198 (40.4%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disposal of child waste</td>
<td>Thrown outside house</td>
<td>48 (62.5%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Buried in the yard</td>
<td>1 (100%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rinsed away</td>
<td>142 (55.2%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Not disposed</td>
<td>25 (60%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mother’s highest education level</td>
<td>No education</td>
<td>60 (58.3%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Primary education</td>
<td>247 (46.6%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Secondary education</td>
<td>77 (28.6%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post- secondary</td>
<td>30 (20%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Father’s highest education level</td>
<td>No education</td>
<td>70 (64.2%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Primary education</td>
<td>218 (48.6%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Secondary education</td>
<td>84 (25%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post- secondary</td>
<td>42 (14.3%)</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
CHAPTER FIVE

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 DISCUSSION

5.1.1 Prevalence of intestinal parasites

This study showed an overall point prevalence of IPI at 43 % among the primary school pupils aged 8-15 years studied in Mbeere North. This prevalence is way above the prevalence of 20.83 % reported by Kinuthia et al. (2012) in a study on selected practices among rural residents contributing to intestinal parasite infections in Njoro District, Kenya. A study determining the prevalence and transmission risk factors for protozoan and nematode infections among children in an Ecuadorian highland community in Ecuador recorded a prevalence of IPI at 46.6 % and attributed this to failure to treat drinking water and failure to wash hands before eating (Rinnes et al., 2005).

This study found E. histolytica as the most prevalent at 36.23%. Ngonjo et al. (2012) found prevalence of E. histolytica amongst school children in Thika District, Kenya to be 14.6 % while Mamandou et al. (2010) reported 18.8 % in school children in Agboville area in Côte d’Ivoire. Duc et al. (2009) in a study on an Agricultural community in Vietnam reported prevalence of 34.8 % amongst primary school children. The prevalence of helminthiasis was 13 %. Muhoho et al. (2014) reported 15.1 % prevalence of soil transmitted helminthes amongst primary school children in Mwea, Central Kenya. The relatively low prevalence of helminthiasis in Mbeere North was attributed to regular deworming in schools (Appendix IX). According to WHO, regular deworming of school children is an important
control method of transmission of helminths in endemic communities (Montresor et al., 2002).

In this study, children of both sexes were similarly infected. However, male pupils recorded a slightly higher percentage infection (44.1 %) than the females (42 %). This could be attributed to the fact that boys are rarely taken to hospital to seek treatment for what their parents consider minor ailments such as stomach ache and hence had slightly higher chances of testing positive for intestinal parasites. Al-Malki (2014) in a study of prevalence of intestinal parasites in Jeddah Saudi Arabia, reported a higher prevalence in males compared to females and associated it with the higher risks for infection in males due to daily activities carried out. Most boys do manual jobs far from their homesteads where they are more likely to eat food and drink water from outlets such as road side kiosks hence increasing their chances of infection. Dhanabal et al. (2014) also observed a higher prevalence in males than females but also pointed out that the infections are likely to be linked to the everyday activities of the people rather than sex. Boys are more likely to interact with contaminated environment (food, water, among others) than girls in the course of playing (Brelet, 2000).

It was found that prevalence of IPI was dependent of age. Younger pupils (11 years and below) had a higher infection rate (48.1 %) than the older ones (37.6 %). This could be attributed to younger children being more likely to engage more in risky practices such as playing activities involving contaminants. Comparatively younger children have relatively poorer hygiene habits since they have little knowledge about hygiene (Mamandou et al., 2010). A study carried out by Ibrahim (2012) amongst children aged 11 years and below
in a hospital in Iraq recorded a prevalence of 30.8% and associated this with factors such as; low immunity against various pathogens leading to less resistance to diseases, poor hygiene and toilet training, overcrowding and low socioeconomic status, in addition to playing anywhere irrespective of the cleanliness or dustiness of play grounds. Moreover, the sale of impure edibles such as contaminated cakes also adversely affects the health of young children 11 years and below as they are likely to buy such edibles on their way to and from school and they have least observance of hygiene measures on the edibles (Ibrahim, 2012).

Kinuthia et al. (2012) identified practices such as failure to wash hands and lack of toilets as being major contributors to high prevalence. Dhanabal et al. (2014) in a study on the prevalence of intestinal parasites in low socioeconomic areas in south Chennai, India, reported that proper hand washing which conventionally interrupts the transmission of some of the parasites is insufficient in areas where water supply / fetching of water takes a lot of manual effort and the tendency is to use water sparingly. This ultimately leads to more transmission by direct and indirect contact.

5.1.2 Distribution of IPI in the three administrative wards
ANOVA test revealed that there was no statistically significant difference in infection rates among the three administrative wards where the pupils were resident. However, pupils from Evurore ward had slightly higher infections rate (46.7 %), followed by Muminji ward (43.07 %). Nthawa ward had the least infections rate (39.13 %). The most prevalent IPI was *Entamoeba histolytica* with a prevalence of 35.5 % in Nthawa, 32.1 % in Muminji and
41% in Evurore. The higher prevalence in Evurore ward could be attributed to poor sanitary practices and lack of safe domestic water since most households (86%) get water from potentially polluted canals and dry riverbed wells (Appendix V). Dry river bed-wells’ water is usually contaminated due to animal and human faeces (Mamandou et al., 2010).

5.1.3 Factors contributing to transmission of intestinal parasites amongst primary school children in Mbeere North Sub-County

The study found that water that is likely to be contaminated from dry river bed wells, rivers and canals were the main water sources in Mbeere North Sub-County. There was a significant association between source of water and prevalence (P < 0.05), an indication that some water sources were more contaminated compared to others such as dry river bed wells. Since dry river bed wells, earth dams, rivers and canals are surface-open, they are more likely to be contaminated by human and animal excreta, bathing and washing clothes in the water sources among other practices. Mail et al. (2011) in a study to establish the factors associated with high prevalence of intestinal parasites in Yemen identified the use of well water as a predictor of intestinal parasitic infections. In sources where water is usually enclosed such as bore holes and tap water, there was no significant association between the source of the water and prevalence.

Practices that may predispose a person to contaminated substances can promote the spread of parasitic infections amongst humans. These include but not limited to consumption of potentially contaminated food and water and general sanitation negligence (Kinuthia et al.,
In Mbeere North sub-county it was observed that such practices are common among the residents and corresponded to increased prevalence amongst school children.

In Mbeere North sub-county, a significant association was found between the type of toilet facility and prevalence of intestinal parasites \((P = 0.029)\). Those who had no toilets often defecated in the bushes and this could have led to contamination of soil, water sources and foodstuffs such as vegetables. Most of the toilets and pit latrines in the rural areas in Kenya have very low standards of cleanliness leading to many flies which occasionally settle on foodstuffs and water as reported by Kinuthia et al. (2012). Water contamination could also occur at home because of the 83.6 % who did not treat their drinking water at home, of whom 47.4 % were infected. This study recorded a statistically significant association between failure to treat drinking water and high prevalence, similar to studies in Yemen (Mail et al., 2011). Another study in Malaysia reported the prevalence of *E. histolytica* at 22.9 % amongst members of an ethnic group who drunk untreated water.

There was no significant association observed between protection of water sources and prevalence of IPI in Mbeere North Sub-County \((P > 0.05)\). However, according to Al-Malik (2014), protection of wells and other water sources reduces chances of contamination and hence reducing infection rates. A statistically significant association was found between toilet overflow with rain water and high prevalence of IPI. Muhoho et al. (2014) associated abundance of water especially during heavy rains with overflowing of pit latrines in areas with high levels of underground water, thus increased risk of infection. Mamandou et al. (2010) reported in a study in Côte d’Ivoire that unprotected water sources are usually
highly polluted by human and animal excreta due to rainfall run off, contaminating them with parasite cysts.

A significant association was found between parents’ education level and prevalence of intestinal parasites where primary school as highest education for mother and / or father was associated with high prevalence of IPIs compared to secondary and tertiary education. This study agrees with Mehraj et al. (2008) in which it was also observed higher intestinal parasitic infections among the poor and socioeconomically disadvantaged communities where overcrowding, inadequate environmental sanitation, low education level and lack of access to safe water are common. Such factors trap communities in a perpetual cycle of indigence and destitution (Hotez, 2009). Blackwell et al. (2015) asserted that prevention of any fecal borne infection needs educated hygienic habits / culture and efficient sewer treatment systems.

Health education in rural and remote areas is required for enhancing adoption of proper hygienic practices and lifestyles. A research done in the villages of Panipat of Haryana State, India on a sample of rural school going pupils aged 8 - 10 years concluded that a need based school health education program developed for different age groups leads to improved personal hygiene practices (Meena, 2009). Richardson et al. (2012) reported that enhanced education programmes on sanitation and hygiene led to 84% reduction in diarrhoeal diseases in Bawa village in western Cameroon. The rate of occurrence of intestinal parasitic infections in a community is indicative of that community's socioeconomic level. Such infections are directly related with educational deficits and
inadequate sanitary conditions and they form an important public health problem (Diaz et al., 2013).

The findings of this study show that intestinal parasitic infections among primary school children aged 8 to 15 years in Mbeere North Sub-County are high. Children from the three administrative wards were similarly infected. The findings also show that poor environmental sanitation, low education level, behavioral and socio-economic factors such as poor access to safe water contribute to transmission of intestinal parasites in the study area; therefore all the three null hypotheses are rejected.

5.2 Conclusions

The following conclusions were made;

i) Intestinal parasitic infections are highly prevalent (43 %) in primary school children aged 8-15 years in Mbeere North sub-County where those 11 years old and below were more infected.

ii) Children from all the three administrative wards were similarly highly infected by IPIs. *Entamoeba histolytica* was the most prevalent IPI at 36.2 % while hookworms recorded the lowest at 3.62 %.

iii) Inaccessibility to safe water was a significant factor in transmission of IPI. Most households used potentially contaminated water from dry river bed wells, canals, earth dams and rivers. Other transmission risk factors included low level of toilet use, failure to treat or boil drinking water and low education level.
The parasite’s prevalence decreased where tap water was used and increased where open surface water was used.

5.3 Recommendations

i) There is need for the national government and the county government to provide public health education to parents and pupils on transmission risk factors for IPIs in Mbeere North Sub-County.

ii) There is urgent need for provision of safe domestic water in Mbeere North Sub-County and to broaden the Mbeere water and sanitation piped water project to reach all the homesteads.

iii) There should be efforts by the national government and the county government to fund community based sanitation projects such as public toilets in all shopping centres and other public places in order to improve the level of sanitation. The general population should be encouraged to construct and use toilets or latrines. Proper use of the toilets should also be encouraged.

iv) Since IPIs are prevalent in children, there is need to extend the school-based deworming program to reach children who do not attend school to reduce contamination of the environment hence lower IPI prevalence.

5.3.1 Suggestions for further studies

i) Whereas this study focused on prevalence of IPI in primary School pupils, further research is needed to establish the prevalence in the general population in Mbeere North and the larger Embu County.
Further research is necessary to establish extent of morbidity and effects such as poor growth, academic performance, anaemia and immunity in primary school children in Mbeere North due to intestinal parasites.
REFERENCES


APPENDICES
APPENDIX I: MAP OF MBEERE NORTH SUB-COUNTY
APPENDIX II: PROCEDURE FOR FORMOL ETHER CONCENTRATION

TECHNIQUE

1. Using a rod, emulsify an estimated 1 g (pea size) of faeces in about 4 ml of 10% formol water contained in a screw-cap bottle or tube

2. Add a further 3-4 ml of 10% v/v formol water, cap the bottle and mix well by shaking

3. Sieve the emulsified faeces, collecting the sieved suspension in a beaker

4. Transfer the suspension to a conical (centrifuge) tube. Add 3-4 ml of diethyl ether

5. Stopper the tube and mix for 1 minute

6. With a tissue or piece of cloth wrapped around the top of the tube, loosen the stopper

7. Centrifuge immediately at 3000 rpm for 1 minute

8. Decant the top three layers then make saline and iodine preparations for microscopic examination of cysts (WHO, 1994)
APPENDIX III: PROCEDURE FOR DIRECT WET MOUNTS PREPARATION.

1. Place a drop of fresh physiological saline on one end of a slide and a drop of iodine on the other end.

2. Using a piece of stick, mix a small amount of specimen, about 2 mg (matchstick head amount) with the saline and a similar amount with the iodine. Make smooth thin preparations. Cover each preparation with a cover glass.

3. Examine systematically the entire saline preparation for helminth eggs, cysts or oocysts. Use 10X objective with the condenser iris closed sufficiently to give good contrast. Use the 40X objective to assist in detection and identification of eggs, cysts and oocysts.

APPENDIX IV: INTESTINAL PARASITES EGGS IDENTIFICATION KEY

![Relative size of helminth eggs](image-url)
APPENDIX V: DEMOGRAPHIC DATA ON RISK FACTORS FOR INTESTINAL PARASITES

<table>
<thead>
<tr>
<th>Variable</th>
<th>Category</th>
<th>No. of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Nthawa</td>
</tr>
<tr>
<td>Main water source at home</td>
<td>Bore hole</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Tap</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Spring</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Canals</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>River</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Earth dam</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Dry riverbed wells</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Rainwater</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Bottled water</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Pond /lake</td>
<td>0</td>
</tr>
<tr>
<td>Water source protected/covered</td>
<td>Yes</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>124</td>
</tr>
<tr>
<td>Water treated/boiled</td>
<td>Yes</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>109</td>
</tr>
<tr>
<td>Toilet facility at home</td>
<td>Flush toilet</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Traditional pit latrine</td>
<td>113</td>
</tr>
<tr>
<td></td>
<td>Ventilated improved pit</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>No facility</td>
<td>0</td>
</tr>
<tr>
<td>Sharing toilet with other households</td>
<td>Yes</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>116</td>
</tr>
<tr>
<td>Rain water overflow in toilets / pit latrines</td>
<td>Yes</td>
<td>87</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>51</td>
</tr>
<tr>
<td>Siblings less than 5 years</td>
<td>Yes</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>73</td>
</tr>
<tr>
<td>Disposal of child waste</td>
<td>Thrown outside dwelling</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Buried in the yard</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Rinsed away</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>Not disposed off</td>
<td>5</td>
</tr>
<tr>
<td>Mother’s highest education level</td>
<td>No education</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Primary education</td>
<td>79</td>
</tr>
<tr>
<td></td>
<td>Secondary education</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Post- secondary</td>
<td>17</td>
</tr>
<tr>
<td>Father’s highest education level</td>
<td>No education</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Primary education</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>Secondary education</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>Post- secondary</td>
<td>20</td>
</tr>
</tbody>
</table>
APPENDIX VI: CONSENT FORM

I am Samuel Kiluu Kamonge, a Master of Science (Applied Parasitology) student at Kenyatta University. I’m researching on the prevalence of intestinal parasites in primary school children in Mbeere North sub-county to establish data beneficial for the public health service in designing control strategies in Mbeere North and other areas of high transmission. The goal is to reduce morbidity from IPI to such levels that the infections are no longer of public health importance.

Confidentiality will be maintained and all children whose stools contain intestinal parasites will be treated with the drugs recommended by health facilities.

Procedure to be followed

Participation in this study will include some questions and specimen examination in order to screen for intestinal protozoa and helminthes. Some fecal specimen will be taken from you for tests. I will record the information from you in a questionnaire.

You have a right to decline participation in this study. You may ask questions related to the study at any time. You may decline to respond to any question and you may stop an interview at any time. You may also withdraw from the study at any time without any consequences to the services you receive from the school now or in future time.

Discomfort and risks

Some of the questions that will be asked are on intimate subject and may be embarrassing or make you uncomfortable. If this happens, you may refuse to answer these questions if you so choose. You may also stop the interview at any time. The interview may take approximately half an hour of your time.
Benefits

If you participate in this study you will help us establish data beneficial for the public health service in designing control strategies in Mbeere North and other areas of high transmission. You will also benefit from being screened for intestinal protozoa and helminthes and if found to have an infection, you will be treated with the drugs recommended by health facilities.

Reward

If you agree to participate in this study you will get a piece of soap that can help you wash your hands after visiting the toilet.

Confidentiality

The interviews and examinations will be conducted in a private setting within the school. Your name will not be recorded on the questionnaire. The questionnaires will be kept in a locked cabinet for safe keeping at Kenyatta University. Everything will be kept private.

Contact information

If you have any questions you may contact Dr. Lucy Kamau on 0722356568 or Dr. Ng’ethe Muhoho on 0721474937 or Kenyatta University Ethical Review Committee Secretariat on chairman.kuerc@ku.ac.ke, secretary.kuerc@ku.ac.ke, ercku2008@gmail.com
Participant’s statement

The above information regarding my participation in the study is clear to me. I have been given a chance to ask questions and my questions have been answered to my satisfaction. My participation is entirely voluntary. I understand that my records will be kept private and that I can leave the study at any time. I understand that I will get the same services from the school today and any other time in future whether I decide to leave the study or not.

Name of participant (Parent/ Guardian) ………………………………………………………

Signature or thumbprint…………………………….. Date ……………………………

Investigator’s statement

I, the undersigned, have explained to the volunteer in a language s/he understands, the procedures to be followed in the study and the risks and benefits involved.

Name of interviewer ………………………………………………………………………

Signature…………………………………………Date …………………………………
APPENDIX VII: PUPILS’ QUESTIONNAIRE

This questionnaire is not an examination. Please give the information as accurately as possible.

The information you will provide will be held with confidentiality.

School Name………………………… Student’s Code …. Age ..... Sex …. Class ..... 

1. Do you wash hands before eating? Yes ( ) No ( )
2. Do you wash hands after visiting toilet? Yes ( ) No ( )
3. Do you wear shoes when going to school? Yes ( ) No ( )
4. Do you wear shoes when going to the farm? Yes ( ) No ( )
5. Do you wear shoes when playing in the field? Yes ( ) No ( )
6. Do you eat any raw food when working in the farm? Yes ( ) No ( )
   If yes specify
   Cassava Yes ( ) No ( ) Sweet potato Yes ( ) No ( ) Fruits Yes ( ) No ( )
   Others (Specify) .........................................................
7. What is the main source of drinking water?
   Piped water
   Piped into dwelling to a public tap Yes ( ) No ( )
   Piped from open well Yes ( ) No ( )
   Piped from open well in the compound Yes ( ) No ( )
   Piped from covered well/borehole Yes ( ) No ( )
   Piped from covered well in the compound/plot Yes ( ) No ( )
   Surface water
   Spring Yes ( ) No ( )
   River/stream Yes ( ) No ( )
   Pond/lake Yes ( ) No ( )
   Rain water Yes ( ) No ( )
   Bottled water Yes ( ) No ( )
8. Do you boil drinking water? Yes ( ) No ( )
9. What kind of toilet facility does your household have?
   Flush toilet Yes ( ) No ( )
Traditional pit latrine          Yes (  ) No (  )
Ventilated improved pit (VIP)   Yes (  ) No (  )
No facility/bush                Yes (  ) No (  )

10. Do you share this toilet with other households? Yes (  ) No (  )

11. If yes, how many households use this toilet?
    Less than 5 (  ) 5-9 (  ) 10 or more (  )

12. Does your toilet have overflow with water during rainy season? Yes (  ) No (  )

13. Do you have a sibling less than 5 years? Yes (  ) No (  )

14. If yes, how does the mother dispose child waste?
    Thrown outside dwelling           Yes (  ) No (  )
    Buried in the yard                Yes (  ) No (  )
    Rinsed away                       Yes (  ) No (  )
    Not disposed off                  Yes (  ) No (  )

15. How often do you cut your nails?                       

16. What do you use to cut nails? Nail cutter Yes (  ) No (  ) Teeth Yes (  ) No (  )
    (  ) Razor blade (Yes) No (  ) Knife Yes (  ) No (  )
    Others (Specify) ..............................

17. What is the occupation of your parents?
    Father.......................... Mother .....................

18. What was your position in the last exam? Position ...... out of ....

19. What is the highest level of education attained by your parents?

<table>
<thead>
<tr>
<th></th>
<th>Father</th>
<th>Mother</th>
</tr>
</thead>
<tbody>
<tr>
<td>No education</td>
<td>(  )</td>
<td>No education</td>
</tr>
<tr>
<td>Primary school</td>
<td>(  )</td>
<td>Primary school</td>
</tr>
<tr>
<td>Secondary school</td>
<td>(  )</td>
<td>Secondary school</td>
</tr>
<tr>
<td>Post-secondary</td>
<td>(  )</td>
<td>Post secondary</td>
</tr>
</tbody>
</table>
APPENDIX VIII: RESEARCH CLEARANCE AND APPROVALS

a) Office of county director of Health, Embu

EMBU COUNTY GOVERNMENT

OFFICE OF COUNTY DIRECTOR OF HEALTH

Mobile: +254 771 204 003/+254 707 192 924
Tel: 254 68 30686/30656
Address: P. O. Box 36 – 60100 Embu Town House
Email: info@embu.go.ke
Web: www.embu.go.ke

Our Ref No: A.9/VOL.VIII/101

Date: 24th April 2017

SCMOH
MBEEE E NORTH

RE. RESEARCH AUTHORIZATION
FOR: KAMONGE SAMUEL KILUU - RE. NO. 156/CE/23947/12

The above named person is a student at Kenyatta University.

He has been authorized to carry out research on “incidence of Intestinal Parasitic Infections in Primary School Children in Mbeere North Sub County in Embu County”

Kindly accord him necessary support.

DR. S.M KANIARU
AG. COUNTY DIRECTOR OF HEALTH
EMBU COUNTY

DISTRICT MEDICAL OFFICER OF HEALTH
MBEEE E DISTRICT
P. O. Box 81 – 60104 SIAKAGO

To Mr. Ngari Schri
Please assist the bearer of this letter.

Allowed to be assisted in the laboratory.
Mr. M. Mashuku to act.

27/4/2017

DISTRICT MEDICAL OFFICER OF HEALTH
MBEEE E DISTRICT
P. O. Box 81 – 60104 SIAKAGO
b) Graduate school, Kenyatta University

KENYATTA UNIVERSITY
GRADUATE SCHOOL

E-mail: dean-graduate@ku.ac.ke
Website: www.ku.ac.ke

P.O. Box 43844, 00100
NAIROBI, KENYA
Tel. 8710901 Ext. 57530

Our Ref: 156/CE/23947/12

DATE: 12th January 2016

Director General,
National Commission for Science, Technology
& Innovation
P.O. Box 36023-00100
NAIROBI

Dear Sir/Madam,

RE: RESEARCH AUTHORIZATION FOR KAMONGE SAMUEL KILUU— REG. NO.
156/CE/23947/12.

I write to introduce Mr. Samuel Kiluu who is a Postgraduate Student of this University. He is registered for M.Sc degree programme in the Department of Zoological Sciences.

Mr. Kiluu intends to conduct research for a M.Sc. Proposal entitled, “Incidence of Intestinal Parasitic Infections in Primary School Children in Mbeere North Sub-County in Embu County, Kenya”.

Any assistance given will be highly appreciated.
c) National Commission for Science, Technology and Innovation, Kenya

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

9th Floor, Utalii House
Uhumu Highway
P.O. Box 30823-00100
NAIROBI-KENYA

Ref. No. NACOSTI/P/17/19291/16772

Date 12th May, 2017

Kamonge Samuel Kiluu
Kenyatta University
P.O. Box 43844-00100
NAIROBI.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on “Incidence of intestinal parasitic infections in primary school children in Mbeere North Sub-County in Embu County, Kenya,” I am pleased to inform you that you have been authorized to undertake research in Embu County for the period ending 11th May, 2018.

You are advised to report to the County Commissioner and the County Director of Education, Embu County before embarking on the research project.

On completion of the research, you are expected to submit two hard copies and one soft copy in pdf of the research report/thesis to our office.

BONIFACE WANYAMA FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Embua County.

The County Director of Education
Embua County.
d) Ministry of Interior and coordination of National Government

THE PRESIDENCY
MINISTRY OF INTERIOR AND COORDINATION OF NATIONAL GOVERNMENT

Telephone: Embu 0202310839
FAX 30040
email: ccembu@gmail.com
When replying please quote ref and date

REF: EBU.CC/ADM/3/37/VOL. II/ (75)  COUNTY COMMISSIONER
DATE: 30th May, 2017
EMBU COUNTY
P.O BOX 3-60100
EMBU

Deputy County Commissioner

MBEERE NORTH

RE: RESEARCH AUTHORIZATION

Please be informed that Kamonge Samuel Kiluu, Research Permit No.
NACOSTI/P/17/19291/16772 of Kenyatta University, Nairobi has been
authorized to carry out research in your Sub-County for a period ending
11th May, 2018.

His research is based on “Incidence of intestinal parasitic infections in
primary school children in Mbeere North Sub-County in Embu County,
Kenya.”

Kindly accord him the necessary assistance.

Collins M. Chacha
FOR: COUNTY COMMISSIONER
EMBU COUNTY

Copy to:
Kamonge Samuel Kiluu
e) Graduate school, Kenyatta University

KENYATTA UNIVERSITY
GRADUATE SCHOOL

E-mail: dean-graduate@ku.ac.ke
kubps@yahoo.com
Website: www.ku.ac.ke

FROM: Dean, Graduate School

TO: Kamonge Samuel Kiluu
C/o Zoological Sciences Department.

DATE: 12th January 2016

SUBJECT: APPROVAL OF RESEARCH PROPOSAL

We acknowledge receipt of your revised Research Proposal as per our recommendations raised by the Graduate School Board of 4th November 2015 entitled “Incidence of Intestinal Parasitic Infections in Primary School Children in Mbeere North Sub-County in Embu County, Kenya”.

You may now proceed with your Data collection, subject to clearance with the Director General, National Commission for Science, Technology and Innovation.

As you embark on your data collection, please note that you will be required to submit to Graduate School completed Supervision Tracking Forms per semester. The form has been developed to replace the Progress Report Forms. The Supervision Tracking Forms are available at the University’s Website under Graduate School webpage downloads.

Supervisors:

1. Dr. Lucy Kamau
   C/o Zoological Sciences Department
   Kenyatta University

2. Dr. Ng’ethe Muhoho
   C/Pathology Department
   Kenyatta University

EO/nn
f) Ethics Review Committee, Kenyatta University

KENYATTA UNIVERSITY
ETHICS REVIEW COMMITTEE

P. O. Box 43844,
Nairobi, 00100
Tel: 87100912
Fax: 8711242/8711575
Email: kuerreview@ku.ac.ke
Website: www.ku.ac.ke

Our Ref: KU/R/COMM/51/799

Date: 9th November, 2016

Kamonge Samuel Kiluu
Kenyatta University
P.O. Box 43844 -00100
NAIROBI

Dear Kiluu,

APPLICATION NUMBER PKU/541/634 - “INCIDENCE OF INTESTINAL PARASITIC INFECTIONS IN PRIMARY SCHOOL CHILDREN IN MBEERE NORTH SUB-COUNTY IN EMBU COUNTY, KENYA” VERSION 2

1. IDENTIFICATION OF PROTOCOL
The application before the committee is with a research topic “Incidence of Intestinal Parasitic Infections in Primary School Children in Mbeere North Sub-County in Embu County, Kenya” - Version 2 received on 28th October, 2016 and discussed on 8th November, 2016.

2. APPLICANT
Kamonge Samuel Kiluu

3. SITE
Mbeere North Sub-County, Embu County, Kenya

4. DECISION
The committee has considered the research protocol in accordance with the Kenyatta University Research Policy (section 7.2.1.5) and the Kenyatta University Ethics Review Committee Guidelines AND APPROVED that the research may proceed for a period of ONE year from 9th November, 2016.

5. ADVICE/CONDITIONS
i. Progress reports are submitted to the KU-ERC every six months and a full report is submitted at the end of the study.
ii. Serious and unexpected adverse events related to the conduct of the study are reported to this board immediately they occur.
iii. Notify the Kenyatta University Ethics Committee of any amendments to the protocol.
iv. Submit an electronic copy of the protocol to KUERC.

When replying, kindly quote the application number above.

If you accept the decision reached and advice and conditions given please sign in the space provided below and return to KU-ERC a copy of the letter.

DR. TITUS KAHIGA
CHAIRMAN ETHICS REVIEW COMMITTEE

Signature: Dated this day of: 30th Nov 2016

cc. Vice-Chancellor
DVC-Research Innovation and Outreach