# INTESTINAL GEOHELMINTH NEMATODES INFECTIONS IN LANGAS PRIMARY SCHOOL CHILDREN IN ELDORET MUNICIPALITY, KENYA

**BY**

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# DECLARATION

## DECLARATION BY THE CANDIDATE

This thesis is my original work and has never been presented for a degree in any other University. No part of this thesis may be reproduced without the prior written permission of the author and/or University of Eldoret.

Luvisia Mark Muranda………………………………. Date…………………………

## DECLARATION BY THE SUPERVISOR

This thesis has been submitted for examination with my approval as University supervisor.

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## ABSTRACT

The prevalence and intensity of intestinal geohelminth nematodes was assessed among school children in Langas Primary School in Eldoret Municipality. The main objective of the study was to determine the relationships between the prevalence and intensities of soil transmitted intestinal geohelminthiases with sanitary resources and conditions, personal hygiene and behavioral habits, and socio- economic status of households.This was a cross-sectional study on randomly selected 285 primary school children. A semi-structured questionnaire was used for the collection of qualitative data. The formal ether concentration technique was used for concentrating helminthes eggs in stool samples and Stoll's technique for approximating the number of eggs per gram of faeces. Chi-square was used to test for differences in proportions, while kruskal-wallis test was used to compare mean rank intensities between groups. Multiple logistic regression was used to identify significant predictors of intestinal geohelminthes infections controlling for confounders. The results showed that 159(55.8%) children had intestinal geohelminth nematode infections with males being more infected than the females (56.8% vs. 43.2%). Individuals aged 11-13 years old had significantly the highest prevalence of the nematode infections (75.4%), $p<0.005$. The specific prevalences of infections were *Ascaris Lumbicoides* 80 (28.1%), *Trichuris trichiura* 50 (17.5%) and hookworms 29 (10.2%) while 71 (44.7%) had multiple infections. The overall mean intensities of the infections were *Ascaris lumbicoides* 256.32 ± 94.90 eggs/g, *T. trichiura* 102 ±14.10 eggs/g and hookworm 120.69 ±77.4 eggs/g of stool.Fruit washing was a significant factor associated with *Ascaris* infection ($p<0.05$). Fruit washing and defecation site at night were significant factors associated with *Trichuris* and hookworm infections ($p<0.05$). Personal hygiene and behavioral habits were identified as major risk factors in the transmission of intestinal geohelminthiases. The findings from this study thus support the need for the regular school-based deworming program for the control of intestinal geohelminth nematodes in primary schools. Other counter measures such as public health education on personal hygiene and behavioral habits, and sanitary resources and their conditions should be adopted to minimize the prevalence of intestinal geohelminth nematodes and reduce the infections.

# DEDICATION

To the loving family of the late Luvisia

Loving mother, Khayenzeri

Loving wife, Cecilia

Loving sons Denis and Kevin, Daughters Caren and Magdalene

Wisdom is God given.

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## DEFINITION OF TERMS AND ACRONYMS

CDC: Centers for Disease Control and Prevention.

DVD: It stands for Digital Versatile/Video Disc,

Disabilities Adjusted Life Span Years (DALY) - It is a measure of overall disease burden expressed as the number of years lost due to ill-health, disability, or early death.

Estate lines: These are houses constructed in single continuous block facing one another,back to back or isolated occupied by two or more families.

Hygiene: The practice of keeping oneself and one's environment clean and free of germs.

Intensity of infection: A measure of the number of eggs per gram of faeces (for intestinal geohelminth nematodes and *Schistosoma mansoni*) or eggs per 10 ml of urine for *Schistosoma haematobium.*

Hand washing: Washing hands with plain or antimicrobial soap and water.

Intestinal geohelminth nematodes: Soil-transmitted intestinal helminthes.

Loeffler's syndrome: It's a disease in which eosinophils accumulates in the lung in response to a parasitic infection.It's caused by an allergic reaction due to the migration of the parasitic worm *Ascaris lumbricoides* through the respiratory tract.It's also known as eosinophilic pneumonia.

Pica: Desire to eat unusual substances such as dirt or soil.

Prevalence of infection: The proportion of individuals with one or more intestinal geohelminth eggs detected in their stool or urine samples at one point in time.

RAST test : It is short for radioallergosorbent test which is a blood test used to determine to what substances a person is allergic. It is a radioimmunoassay test to detect specific IgE antibodies to suspected or known allergens.

Sanitation: Formulation and application of measures designed to protect public health. It's the science of maintaining a healthful, disease- and hazard-free environment.

Slum: It can be defined as an area of settlement characteristized by lack of adequate water supply, inadequate sanitation, and insecure tenure for its inhabitants, and poor structural quality of housing units, unsafe physical environment and insufficient living area.

Splashing Method: Scattering or propelling a fliud or water about in flying masses to remove dirt from a surface or floor.

Subjects/participants:The school children that provided stool samples and answered questionnaire.

TV: Television

WHO: World Health Organization

# CHAPTER ONE

## 1.0 Introduction

Intestinal geohelminth nematode infections are acquired from an environment contaminated by the worms' infective stages, and so the species are often considered collectively as if they are a single entity. However, each species is responsible for a separate set of signs and symptoms, in fact for a separate disease (WHO, 2010).

There are four major Intestinal geohelminth nematodes which infect humans; *Ascaris lumbricoides, Trichuris trichiura* and hookworms (*Ancylostoma duodenale* and *Necator americanus*) (WHO, 2010). The four species of intestinal geohelminth nematodes sometimes occur concurrently in the same community, resulting in multiple infections in an individual at a time.

The World Health Organization (2010) estimates the global prevalence of intestinal geohelminth infections as over 1 billion cases of *Ascaris lumbri*coi*des,* 740 million cases of *Necator americanus* and *Ancylostoma duodenale,* and 795 million cases of *Trichuris trichiura.* Geolhelminthiases affect 500 million children and nearly a billion adults (Albonico *et al,* 1994., Chan, 1997).

Current estimates are that at least one-quarter of the world's population is infected with intestinal geohelminth nematodes with about 90 million school-aged children and the poor being infected in Africa (WHO, 2010). Ascariasis and trichuriasis are two of the most prevalent intestinal geohelminth nematode infections affecting almost two billion people world-wide (De Silva *et al*., 2003). These two infections, ascariasis and trichuriasis, are generally most prevalent among rural communities and urban areas in Sub-Saharan Africa, the Americas, China and east Asia where sanitation facilities are inadequate and minimal hygiene is observed (WHO, 2010).

Intestinal geohelminth nematodes do not replicate within the human host and the diseases they cause is roughly proportional to the intensity of infection (Ghaffar, 2010). In order to be infective their eggs have to be released into environment where they are embryonated (*A.lumbricoides* and *T.trichiura*) or hatched into infective larvae (hookworms) (Ayanda *et al.,* 2010).

The high levels of intestinal geohelminth nematodes is attributed to indiscriminate disposal of human faeces, poor personal hygiene, and inadequate supply of clean water (Uneke *et al,* 2009). Intestinal geohelminthiases are of great importance in the health of many populations in third world nations where illiteracy, poverty, and associated poor environmental sanitary practices have been implicated in the heavy burden of infections among children (Oyerinde, 1999; Wagbatsoma and Essien, 2000).

High incidences of intestinal geohelminth nematode infection, manifestation and multiparasitism affect the health of young children (WHO, 2002). This phenomenon is highest within the communities with inferior sanitary and environmental conditions (De Silva *et al*., 1996; Gunawardena *et al*., 2004).

Intestinal geohelminth nematodes flourish predominantly in the urban slums and rural areas where there is no functional latrine system (Gunawardena *et al*., 2004). The soil and water around the villages or communities become contaminated with egg laden faeces deposited in the fields, bushes and playgrounds. Persistence of intestinal geohelminthiases in such communities is closely linked to contamination of the environment with the faeces of infected people (Maipanich *et al*., 1995; Gyoten *et al*., 2010., Coelho *et al.*, 2001).

Intestinal geohelminth nematodes infection in school-age children is often asymptomatic and only rarely results in death but its effects may contribute substantially to chronic morbidity wherever access to effective sanitation and hygiene is minimal (WHO, 2002; WHO, 2010). However, approximately 300 million people with heavy intestinal geohelminth nematode infections suffer from severe morbidity that results in more than 150,000 deaths annually (Crompton, 1999; Montresor *et al.*, 2002).

The symptoms of intestinal geohelminth nematodes infections are nonspecific and become evident only when the infection is particularly severe, with the heaviest infections occurring in school-age children (Warren *et al.*, 1993; Brooker *et al.*, 2000; WHO, 2010).

Intestinal geohelminth nematode infections aggravate malnutrition and amplify rates of anemia. They may decrease nutrients uptake by the host or functionally increase the host’s nutrients requirements (De Silva *et al.*, 1996; El-Nofely and Shaalan, 1999). The chief form of morbidity caused by intestinal geohelminth nematodes is the negative effect on nutritional status that includes malabsorption of nutrients, loss of appetite and reduction of food intake (WHO, 2010). In addition the diseases may be associated with may cause intestinal bleeding, rectal prolapse, and complications requiring surgical intervention, such as intestinal and biliary obstructions (WHO, 2010).

## 1.1 Problem Statement

Growth and development disabilities are significant and frequently undetected health problems in developing countries such as Kenya. Malnutrition associated with parasitoses especially intestinal geohelminth nematode infections may be a major factor for retarded physical growth and cognitive development among infants and children from rural areas, contributing significantly to school absenteeism and poor academic performance ( WHO, 2002; WHO, 2005; Ziegelbauer *et al.*, 2010; El-Nofely and Shaalan, 2010). Hadju *et al*. (1996, 1997) found that treatment of intestinal geohelminthes-infected schoolboys improved their appetite and growth in areas where ascariasis and poor growth were highly prevalent.

## 1.2. Objectives

### 1.2.1 General Objective

To determine the relationships between the prevalence and intensities of intestinal geohelminth nematodes infections in school children to their sanitary resources and conditions, personal hygiene and behavioral habits, and socio- economic status of their households.

### 1.2.2 Specific Objectives the Study

1. To determine the prevalence and intensities of intestinal geohelminth nematode infections among school children of Langas primary school.
2. To investigate and compare the prevalence and intensities of the infections by gender and age groups.
3. To determine the frequency of multiple infections of intestinal geohelminth nematodes by age and gender.
4. To establish how the children's levels of sanitary resources and conditions, personal hygiene, behavioural habits and the parents or guardians socio-economic status affected the prevalence and intensities of the infections.

## 1.3 Study Hypotheses

**Null hypothesis (H0) 1**: There is low prevalence and intensities of intestinal geohelminth nematode infections among school children of Langas primary school.

**Null hypothesis (H0) 2**: The prevalence and intensities of the intestinal geohelminth nematode infections is independent of gender and age groups.

**Null hypothesis (H0) 3**: The frequency of multiple infections of intestinal geohelminth nematodes infections is independent of age and gender.

**Null hypothesis (H0) 4**: There are no relationships between the children's levels of sanitary resources and conditions, personal hygiene, behavioural habits and the parents' or guardians' socio-economic status with the prevalence and intensities of the infections.

### 1.4 Justification of the Study

The prevalence of human infections with intestinal geohelminthiases can vary widely with location even within a region in the country (Thiongo *et al*., 2001; Gunawardena *et al*., 2004). Langas primary school has its own unique socio-economic and environmental sanitary characteristics that could influence the prevalence and intensity of intestinal geohelminth nematodes. The results of this study could be useful to both researchers and the Ministry of Health and Sanitation in planning and implementing control programs for intestinal geohelminth nematode infections in the study area and other areas with similar conditions.

# CHAPTER TWO

## 2.0 Literature Review

### 2.1 Epidemiology of Soil-transmitted Human Intestinal Nematode Infections

Ascariasis is one of the commonest and most widespread human intestinal geohelminth nematode parasites throughout the developing countries. WHO ( 2010) estimates the global prevalence of acariasis in Africa as 173 million out of over 1 billion cases of infection worldwide.

Ascariasis has a faecal-oral transmission route. Infection occurs when eggs present in contaminated food, water, soil, dirty unkempt fingers and objects are ingested. *Ascaris* eggs have especially "sticky" nature and they have been found adhered to money, agricultural produce, cutlery, crockery, fingernails and hands (Udonsi, 1984; Ekpenyong *et al*., 2008). In highly endemic regions *Ascaris* eggs may be found in household dust and air from where they are inhaled or swallowed (O'larcain and Holland, 2000). Soils around latrines and school yards have been found contaminated with *Ascaris* eggs.

In most nations where intestinal geohelminth nematodes are endemic, schoolchildren experience the highest morbidity, particularly with ascariasis and trichuriasis (O'larcain and Holland, 2000; Sorensen *et al*., 2011). Ascariasis can result to considerable morbidity and impaired physical fitness and poor school performance of children (WHO, 2002; Sorensen *et al.,* 2011).

In Kenya the highest rate of ascariasis has been reported in primary school-aged children in a rural village in southwestern Kenya, Kisumu (Peterson *et al.*, 2011). The age – specific prevalence recorded was 11-13 years. Thiongo *et al.* (2001) reported prevalence rate of 16.5% ascariasis in children aged 5-9 years and 6-11 years in Usigu and Bondo divisions respectively. In a related study conducted in Nairobi city, the prevalence rate of 6.5% was recorded in all age strata among primary schoolchildren (Mwanthi *et al*., 2008).

The risk factors predisposing children to ascariasis are socio-economic, poor environmental sanitation and poor personal sanitary hygiene such as consumption of unwashed vegetables and fruits, failure to wash hands after defecation and before eating meals (Coelho *et al*., 2001; Gyoten *et al*., 2010). In one field study to determine the presence of transmissible forms of enteroparasites, 1.3% of washed samples of vegetables were found contaminated with *Ascaris* eggs (Coelho *et al.*, 2001). In other studies, 2% *A. lumbricoides* eggs were detected on unwashed vegetables mostly among leafy vegetables such as lettuce and parsely (Avcioglu *et al.*, 2011) and also in imported vegetables (Raisanen *et al.*, 1985).

Recent investigations showed that poor socio-economic status is among the key factors linked with high prevalence and intensities of ascariasis (Ezeagwuna *et al.*, 2010). Although intestinal geohelminth nematode infections occur predominantly in rural areas, social and environmental conditions in many unplanned slums of developing countries are ideal for the persistence of ascariasis and the schoolchildren bear the burden of infection (Anantaphruti *et al.*, 2004; Peterson *et al.*, 2011).

It was reported in Southern Thailand that schoolchildren without latrines in their homes and their parents are low income earners had high prevalence and infection rates of ascaris (Ananthaphruti *et al.*, 2004). In addition, the level of mothers' education affects the infection status of children particularly with ascariasis (Sorensen *et al.*, 2011).

Trichuriasis is also one of the commonest intestinal geohelminth nematodes infecting humans especially in warm and humid tropical countries. The global prevalence of trichurisias is estimated as 795 million cases representing about 31.36% of the total worldwide infection by intestinal geohelminth nematodes. Africa takes the second largest burden of infection with 162 million cases reported (WHO, 2010).

Humans are the primary host for infections caused by *T. trichiura* but the species has been detected in some non-human primates (Horri and Usuii, 1985). Infection is acquired through ingestion of infective eggs from contaminated food, hands or water. Trichuriasis is associated with poverty, inadequate sanitation and hygiene, and certain sanitary behaviors such as defaecating in the open fields (Ezeagwuna *et al.*, 2010; Uneke *et al*., 2009).

Human infection with the parasite may be asymptomatic or the cause of anaemia, abdominal pain, dysentery-like symptoms and impairment in growth and mental function

(Stephenson *et al.,* 1989; Nokes *et al.,* 1992). The prevalence of trichuriasis increases during childhood and maintains a relatively constant value in childhood (Bundy *et al.,* 1987). Some workers found that intensity of trichuriasis decrease linearly with age and without marked sex difference. Children below 10 years of age tend to have higher intensity of trichuriasis than older age groups (Thiongo *et al.*, 2001).

In Kenya, variable prevalences have been reported in the arid, semi arid, highlands and Lake Region (Otieno *et al*., 1985). The prevalence of 21.85% and 24% in Bondo and Kisumu districts was recorded respectively (Olsen *et al.,* 1998; Thiongo *et al*., 2001). In other studies prevalence rates of 3.6%, 30.6% and 55.2% were reported among schoolchildren in southwestern Kenya (Peterson *et al.*, 2011), Nairobi city (Mwanthi *et al.*, 2008) and Busia (Brooker *at al.*, 2000) respectively.

Hookworm infection in humans is caused by two species, namely *Ancylostoma duadenale* which is more prevalent in the Middle East, North China, Europe and South East Asia; and *Necator americanus* which is prevalent in Central and South America and Tropical Africa (WHO, 2010).

Globally, the prevalence of hookworm disease is estimated as 740 million cases of *N.americanus* and *A.duodenale*, with Africa harboring the largest disease burden of 198 million cases (WHO, 2010). It was estimated that these hookworm infections annually account for 65,500 human deaths and 22.1 million disabilities adjusted life span years (WHO, 2002; De silva *et al*., 2003).

Hookworm disease is transmitted through contact with contaminated soil with third-stage infective larvae, which either penetrate the skin (*N.americanus and A.duodenale*) or when they are ingested *(A.duodenale*) (Hawdon and Hotez, 1996). Human infection with hookworm is both wide spread and clinically important. Hookworms contribute significantly to iron deficiency (Olsen *et al.,* 1998) and impair the intellectual, cognitive and physical development of infected children (Stephenson *et al.,* 1989; Richared, 2003).

In Kenya hookworm infection was found to be more prevalent in the coastal region and western Kenya (Olsen *et al.,* 1998; Thiongo *et al*., 2001). The percentage prevalence of 36% (Thiongo *et al.,* 2001) and 63% (Oslen *et al.,* 1998) were reported in Bondo and Kisumu districts respectively. Booker *et al*. (2000) estimated the percentage prevalence and intensity of infection of hookworm infection among schoolchildren in Busia District as 77.5% and 8.6% respectively. In southwestern Kenya and Nairobi city, prevalence of 9% and 1.6% was registered respectively (Mwanthi *et al*., 2008; Peterson *et al.,* 2011).

### 2.1.1 Transmission, Pathogenesis and Clinical Features of Human Ascariasis

Ascariasis is spread by faecal pollution of the environment from where its eggs are transmitted through accidental ingestion of soil. A person becomes infected by swallowing infective eggs in contaminated food or hands and contaminated green vegetables and fruits (Raisanen *et al*., 1985; Erdogrul and Sener, 2005). However, deliberate ingestion of contaminated soil, pica, by children and pregnant mothers is a significant risk factor in transmission of Ascariasis (Saathoff *et al*., 2002).

The ascariasis initial pathology is associated with migrating larvae; its severity depending upon the number of invading larvae, the sensitivity of the host, and the host's nutritional status.  People repeatedly infected become hypersensitive (Kightlinger *et al.,* 1996) and lead to acute interstitial nephritis which is an important cause of acute renal failure (Jung *et al*., 2004), and migrating larvae may cause inflammatory reactions in the liver and lungs, including pulmonary eosinophilia and granuloma formation. The reactions lead to pneumonitis and a condition known as Loeffler's syndrome (Weller and Leder, 2010).

Pathology induced by adult worms include blockage of the intestines (Gunawardena and Gunawardena, 2008) and wandering *A lumbricoides* may sometimes reach the vermiform appendix and its presence there may remain silent or incite pathology leading to acute appendicitis (Wani *et al.,* 2010). The rare fatalities usually result from intestinal obstruction (Rodriguez *et al.*, 2003) or biliary ascariasis (Wangsaensook *et al.,* 2010).

Ascariasis is classified by severity of manifestations, which usually correlates with parasite burden. Five types are recognized: type A is often asymptomatic, type B causes permanent growth retardation in children, type C is clinically overt and is characterized by intermittent abdominal pain, nausea, anorexia, diarrhea, type D causes acute complications that often require hospitalization (intestinal obstructions, biliary ascariasis, appendicitis),and type E is most severe frequently fatal disease.

Generally, adult *A. lumbricoides* infections involving only a few worms are usually asymptomatic, but as the worm load increases, symptoms of abdominal discomfort, nausea, vomiting, weight loss, fever, and diarrhea develop. Allergic manifestations in hypersensitive persons lead to pneumonitis, cough, low-grade fever, and eosinophilia. Large numbers of worms may form a bolus and cause intestinal obstruction (Gil *et al*., 2006). Stimulation causes adult worms to become erratic and invade the appendix and bilary and pancreatic ducts. Worms may enter and block small orifices. Migrating adults have been vomited and passed from the nose and mouth, anus, umbilicus, and lacrimal glands.

The worms can perforate the intestines and enter the peritoneal cavity, the respiratory tract, urethra (Fagan and Prescott, 1993) and vagina (Cousin *et al.*, 1992), and even the placenta and fetus. The worms may cause urinary retension in both children and adults (Gupta *et al.*, 2009). Excessive worm loads, especially among the malnourished, can lead to nutritional impairment because the worms interfere with the absorption of proteins, fats, and carbohydrates.

**2.1.2 Transmission, Pathogenesis and Clinical Features of Human Trichuriasis**

Most infections are acquired by eating infective eggs in contaminated soil, foods, or drink. *Trichuris* ova can be found in surface water, ground water and sea water but not in drinking treated water (Pannatat and Jongwutiwes, 2010). They can also be present in feaces, soil, sludge, night soil, sewage, crops and beaches. A single infection may last for several years. Humans are the main host, but not the only reservoir for *T. trichiura*. Recent research verified by the application of molecular techniques (PCR) that dogs are a reservoir for *T. trichiura*, as well as T.vulpis (Pannatat and Jongwutiwes, 2010).

In young children, heavy infections may lead to petechial hemorrhage and chronic diarrhea (Huang *et al*., 2003), oedema, inflammation, rectal prolapse, iron deficiency anaemia and mucosal bleeding (Tolan and Steele, 2011) and ileocecal valve swelling (Sharif *et al.,* 2011). Small amounts of blood (0.005 ml per worm) are lost each day by seepage at the attachment site. Nutritional changes can cause stunted growth and clubbing of fingers and growth retardation (Tolan and Steele, 2011).

The parasite *T. trichiura* lives primarily in the cecum and appendix but can also be found in large numbers in the colon and rectum. Patients with fewer than 100 worms are frequently asymptomatic; however, they may present with lower abdominal discomfort, flatulence, and constipation (Stephenson *et al*, 1989; Nokes *et al.*, 1992; Tsieh, 1999). *Trichuris* dysentery syndrome is observed in heavy infections and characterized by bloody mucoid diarrhea, small frequent stools, tenesmus (painful straining), anemia, and growth retardation (Tolan and Steele, 2011). Patients with heavy infection have hundreds to thousands of worms and may present with lower or epigastric pain, vomiting, abdominal distension, anorexia, weight loss, anemia and rectal prolapse (Tolan and Steele, 2011).

### 2.1.3 Transmission, Pathogenesis and Clinical Features of Human Hookworm Disease/Infection

Humans acquire hookworm disease when the infective larval stages (known as third-stage larvae or L3) living in the soil either penetrate through the skin (both *N. americanus* and *A. duodenale*) or when they are ingested for *A. duodenal*e (Ghaffar, 2010). It has also been reported that *N. americanus* L3 will invade the buccal epithelium if they enter through the mouth. The L3 stages, approximately 600 microns in length, are developmentally arrested and can live in the soil for weeks if there is appropriate warmth, shade, and moisture (Brooker *et al*., 2004). However, they quickly become desiccated if exposed to direct sunlight, drying, or salt water. The L3 lie and wait in the soil to pierce the skin of the human host. They move very little horizontally, but migrate upwards on blades of grass (Brooker *et al.*, 2004).

Secondary bacterial infection may also occur at "Ground itch" sites. Large numbers of larvae migrating through the lungs at the same time may cause pneumonitis. In the small intestine, worms attach to the mucosa by the buccal capsule. As the worms feed on the mucosa they cause a considerable amount of blood loss. The worm ingests mucosal tissue with blood; much of the blood is then excreted into the lumen of the host's intestine (Hotez *et al*., 2004).

Blood also is lost by seepage around the attachment site. When the worm changes attachment sites, the wound oozes blood for several days. One *A. duodenale* is estimated to be responsible for the loss of 0.15 to 0.26 ml blood per day, and one *N. americanus* for the loss of 0.03 ml per day (Cheesbrough, 2005; Hotez *et al.*, 2004). An anti-coagulant secreted in the buccal capsule of these worms also contributes to blood loss.

In pregnant women, anemia resulting from hookworm disease has been associated with low birth weight, impaired milk production, and increased risk of death for both the mother and the child. In children, chronic hookworm infection has been shown to impair physical and intellectual development, reduce school performance and attendance, and adversely affect future productivity and wage–earning potential (Becker *et al.,* 2011). After contact with contaminated soil, initial skin penetration of larvae, usually involving the feet, can cause a stinging or burning sensation followed by pruritus and a papulovesicular rash that may persist for 1 to 2 weeks (Bethony *et al.,* 2006).

Patients with hookworm infection often are asymptomatic. The major clinical manifestations of hookworm disease are the consequences of chronic intestinal blood loss. Iron-deficiency anemia occurs and hypoalbuminemia develops when blood loss exceeds the intake and reserves of host iron and protein (Stoltzfus *et al*., 1997). Depending on the status of host iron, a hookworm burden (that is, the intensity of infection, or number of worms per person) of 40 to 160 worms is associated with hemoglobin levels below 11 g per deciliter (Lwambo *et al.,* 1992). However, other studies have shown that anemia may occur with a lighter hookworm burden (Olsen *et al*., 1998). Because of the clinically significant blood loss and the ingestion of serum proteins, hypoproteinemia may also develop, which clinically manifests as weight-loss, and edema. Chronically infected children with moderate and heavy hookworm infections suffer from intestinal blood loss resulting in iron deficiency, which can lead to anemia as well as protein malnutrition. Prolonged iron deficiency associated with hookworms in childhood can lead to physical growth retardation and cognitive and intellectual deficits (Lwambo *et al.,* 1992).

Pneumonitis associated with migrating larvae is uncommon and usually mild, except in heavy infections. Colicky abdominal pain, nausea, and/or diarrhea and marked eosinophilia can develop 4 to 6 weeks after exposure or heavy hookworm infections. After oral ingestion of infectious *Ancylostoma duodenale* larvae, disease can manifest with pharyngeal itching, hoarseness, nausea, and vomiting shortly after ingestion (Olsen *et al.,* 1998).

Cough subsequently occurs in *A. duodenale* and *N. americanus* hookworm infection when larvae migrate through the lungs to cause laryngotracheobronchitis, usually about 1 week after exposure. Pharyngitis can also occur. Most of the physical signs of chronic hookworm infection reflect the presence of iron-deficiency anemia. In addition, anasarca from extensive plasma hypoproteinemia is associated with edema of the face and lower limbs and with potbelly. The skin becomes waxy and acquires a sickly yellowish color, a feature of tropical chlorosis (Olsen *et al.,* 1998). A moderate or heavy hookworm burden results in recurrent epigastric pain and tenderness, nausea, exertional dyspnea, pain in the lower extremities, palpitations, joint and sternal pain, headache, fatigue, and impotence (Anyaeze,2003; Becker *et al.*,2011).

## 2.2 Approaches to the Diagnosis, Prevention and Control of Soil-Transmitted Human Intestinal Infections/Diseases

The pneumonitis, eosinophilia, and intestinal symptoms of symptomatic ascariasis are similar to those caused by other infectious agents. As a result, it is rarely diagnosed on clinical grounds alone. Infections before the appearance of eggs in the faeces, infections with only male worms, and extra intestinal infections are difficult to diagnose (Scott, 2008). Radiologic computed tomography (CT) and sonographic examination may reveal adult worms in the intestine and bile ducts, but definitive diagnosis requires finding characteristic eggs in feces (Scott, 2008). Eggs are usually so numerous in any infection involving female worms that simple microscopic examination of a faecal smear is all that is necessary.

Concentration techniques involving flotation or sedimentation of eggs also may be used (Cheesbrough, 2005; Scott, 2008). Kato-katz and Stoll's techniques are available for estimation of the intensity of intestinal geohelminth nematode infections on the basis of the number of eggs in a measured stool sample (Goodman *et al.,* 2007; Odongo-Aginya *et al.,* 2007). By far the most effective method to control ascariasis, as well as other soil-transmitted helminthiases is sanitary disposal of faeces (Alum *et al.,* 2010; Drangert, 2010). In some areas, this requires changing centuries-old habits and educating the population (Gunawardena *et al*., 2005). Mass treatment programs most frequently focus on delivery through the school system which is more efficient than community-based or household distribution. In addition, School-aged children tend to have the highest intensity of infection (Scott, 2008). These programs have been initiated in many parts of the world and, in some Asian countries; efforts are being made to deworm all school children. Mebendazole, the drug used, is effective against numerous intestinal nematode infections and causes few side effects. Levamisole is also useful, as are pyrantel pamoate, piperazine citrate, thiabendazole and albendazole (Scott, 2008).

Care must be taken in treating mixed helminthic infections involving *A. lumbricoides*, because an ineffective ascaricide may stimulate the parasite to migrate to another location. Persons in whom asymptomatic ascariasis is detected incidentally should be treated to prevent the possibility of a future abnormal migration of these large worms into extra intestinal sites. The symptoms of trichuriasis are nonspecific, but the infection is readily diagnosed by identifying eggs in the faeces. In heavy infections, the stools are frequently mucoid and contain Charcot-Leyden crystals. Concentration methods are required for diagnosis in light infections. The eggs appear yellow-brown with characteristic barrel shape with prominent bipolar blister-like plugs (Cheesbrough, 2005). In heavy infections, the parasite can be seen in the rectal mucosa by using proctoscope (Sharif *et al*., 2011).

Sanitary disposal of faeces is the best control measure. However, effective anthelmintic therapy is available. The drug of choice for trichuriasis is mebendazole. A single dose of 500 mg can results in a cure rate of 40-75%. Albendazole is an alternative drug. However, its efficacy for trichuriasis is slightly lower than for mebendazole (Koski and Kulkarni, 2011). Diagnosis of hookworm is made by demonstrating eggs in stool specimens. The two species cannot be distinguished on the basis of their eggs. Direct microscopic examination of the stools may suffice in heavy infections, but a concentration method should be used in most cases mainly zinc sulfate flotation or formalin-ethylacetate concentration (Ghaffar, 2010).

An estimate of the intensity of infection can be made on the basis of the number of eggs in a measured faecal sample. Specimens should be examined promptly since rhabditiform larvae may develop and hatch from the egg within 12 hours. When larvae are present in the faeces, they must be differentiated from those of other nematode species normally parasitic in animals which can infect humans. These include larvae of *Trichostrongylus* species, *Ternidens deminutus*, *Oesophagostum* species, and *Strongyloides fuelleborni* (Cheesbrough, 2005).

Hookworm can be controlled in a population by sanitary disposal of fecal material and avoidance of contact with infected fecal material sanitary, treatment of infected persons, wearing of shoes, and health education. Treatment with mebendazole, 200 mg, for adults and 100 mg for children, for 3 days is effective. In many developing countries, mebendazole is administered as a single dose of 500 mg; with this regimen the cure rates can be as low as 20–30% (Ghaffar, 2010). Ant-helminthic treatment should be supplemented with an improved diet, including administration of iron.

### 2.3 Behavioural habits, Hygiene and Socio-economic Aspects Related to Prevalence of Human Intestinal Geohelminth Nematode Infections/Diseases

Transmission of intestinal geohelminth nematode infections is predominantly related to human behavioural habits with regard to cleanliness, personal hygiene and defecation (Mascarini-Serra, 2011) and socio-economic status (Okon and Oku, 2001). Recent findings have established that suboptimal hygiene knowledge and behaviour (hand washing and hand washing with soap) among African children contribute immensely to helminth infections (Pengpid and Peltzer, 2011).

Khan *et al*.,( 2004) reported high prevalence of ascariasis, trichuriasis and hookworm disease among the children of age group 5 - 15 years. This was attributed to the facts that children in this age start going outside and to schools, they do not take much care about the cleanliness of their hands and clothing, they take unhygienic food stuffs and they do not wash their hands frequently, particularly before meals and after going to toilet. A previous study in Nigeria has associated prevalence of geohelminthes infections with change in behavioural habits as children grow up. It was reported that subjects in the older age group were the most heavily infected followed by the 5–9 year age group (Okon and Oku, 2001). Playing habit of children with soil is also an important factor for prevalence and intensity of ascariasis, trichuriasis and hookworm disease (Naish *et al* ., 2004 ; Jeffrey *et al*., 2006). Children in the 5-9 age group play in the environment and are more prone to exposure to contaminated soil, high level of soil contact activity and low personal hygiene (Naish *et al* ., 2004 ; Jeffrey *et al*., 2006).

The most important factor for regular hand washing is the type of preceding activity such as field work or defecation or subsequent activity such as food consumption (Schmidlin *et al*., 1998). In a cross-sectional study carried out among children in rural Malaysia, the behaviour of not washing hands before eating and not washing hands after defecation were key factors significantly associated with ascariasis, trichuriasis and hookworm disease (Nasr *et al.*, 2013). In a related study in pre-school and school children in rural

Southwest China, sanitation behaviors including hand washing after using the bathroom or before eating significantly and positively correlated with the probability of intestinal geohlminths infections (Wang et al., 2012).

Other unhygienic behaviors associated with ascariasis, trichuriasis and hookworm disease include consumption of unwashed fruits, vegetables, and unboiled drinking water (Wang et al., 2012). Geophagy (Saathoff *et al.,* 2002; Luoba *et al.*, 2005) and not wearing shoes (Chongsuvivatwong *et al.,* 1996) reportedly increase an individual's risk of contact with eggs or larvae. The impact of sanitation on intestinal geohelminth nematodes infections is limited to sanitation interventions which entail improvements in clean water supply (Brown et al., 2011). When a tap is available within the household, or shared with a close neighbor, per capita water use can go up from 10–30 litres/person/day to 30–100 litres/person/day (Brown et al., 2011). Greater volumes of water available to a household tend to result in better hygiene, including increased hand washing.

Exposure to frequent supply of unsafe drinking water, inadequate sanitation and excreta disposal has been reported as factors influencing the prevalence of ascariasis, trichuriasis and hookworm disease (Kang, 1998). Few studies have shown that poor quality drinking water is an unlikely source of infection, as eggs tend to sink in water (Esrey, 1991). However, improved water supply interventions in the USA have shown a 37% decreased risk of ascariasis, trichuriasis and hookworm disease in groups supplied with piped water in households (Esrey, 1991).

Sanitation and hygiene behavior have proven to be substantial contributors to a sustainable control of ascariasis, trichuriasis and hookworm disease (Bartram and Cairncross, 2010). However, the improvements of hygiene behavior are of a higher complexity than the regular administration of anthelminthic drugs to school children. The availability of sanitary facilities such as latrines does not necessarily mean that they are being used (Mara et al., 2010). People living in households with latrines mostly used them, but they also practice open defecation (Schmidlin *et al*., 1998).

The high prevalence of ascariasis, trichuriasis and hookworm disease has been reported among those using pit latrines. This could be due to the poor hygienic maintenance of the pit latrines in the households which easily enhance the transmission and distribution of these parasites through house flies and cockroaches (Amuta *et al.,* 2009). Additionally, most latrines are not designed for use of, and may not be used by, small children. They might be afraid to use them for the risk of falling in, bad smells, or the fear of dark spaces (Brown e*t al.,* 2011). Defecation on the floor is common and potentially seen as the most practical option until the child is trained to use a latrine (Brown *et al.*, 2011).

Over one billion people practice open defecation, mostly in rural areas (UNICEF and WHO, 2012). Defecation in the open fields and bushes is still commonly practiced among households possessing a latrine (Schmidlin *et al*., 1998). Positive associations between open defecation and higher prevalence of intestinal geohelminth nematode infections have been noted by other studies as well (Bradley and Chandiwana, 1990; De

Silva *et al.,* 1994). Several factors that significantly correlate with socioeconomic status have been implicated in various studies of prevalence and intensity of ascariasis and trichuriasis (Traub *et al.,* 2004). In a study carried out in West Java, Indonesia, children who lived in homes with an electricity supply and a cement floor, had low prevalence rates (Pegelow *et al.*, 1997). In a related study, ascariasis was statistically associated with lack of electricity, lack of refrigerator, use of wood as cooking fuel, dirt floor, water supply from communal source and living in a locality classified as having very high poverty (Morales-Espinoza *et al.,* 2003). In a study conducted in Taabo, Côte d'Ivoire, participants in possession of household assets such as electricity, latrine, television, and a motorcycle had low prevalences of ascariasis, trichuriasis and hookworm disease (Schmidlin *et al*., 1998). This could be due to the fact that socio-economically stable families can keep personal hygiene and cleanliness of house hold and their belongings (Khan *et al.,* 2004).

Monthly income of families is also very significant in intestinal geohelminth nematode infections. In a study of prevalence, distribution and risk factors of intestinal helminthic infestation in district Bagh (Azad Kashmir), very high prevalence of intestinal geohelminth nematode infections (34.33%) was reported among subjects with income less than Rs 3000/- per month as compared to the subjects with income more than Rs 3000/-per month (8.22%) (Khan *et al.,* 2004).

Ascariasis, trichuriasis and hookworm disease are prevalent in children who are not dewormed (Oyewole *et al*., 2007). Therefore, current geohelminthiases control programs focus on regular administration of anthelminthic drugs to school children (WHO, 2003).

However, this approach of preventive chemotherapy does not prevent re-infection, which might occur rapidly (Quinnell et al. 1993; Jia et al., 2012). Current control efforts emphasize drug interventions, and do not give sufficient attention to hygiene behavior, clean water, and adequate sanitation (Singer and Castro, 2007; Ziegelbauer *et al.*, 2012)

# CHAPTER THREE

## 3.0 Materials and Methods

### 3.1 Study Area

The study was carried out in Langas Primary school located in Pioneer education zone in Eldoret Municipality. The school is situated in the large urban slum area of Langas where majority of the pupils reside. Langas is one of the populous, low-income areas of Eldoret municipality. It is located approximately 8 km south of Eldoret town Central Business Center (Fig 3.1). Eldoret is the headquarters of Uasin Gishu County in Rift Valley Province, Kenya.

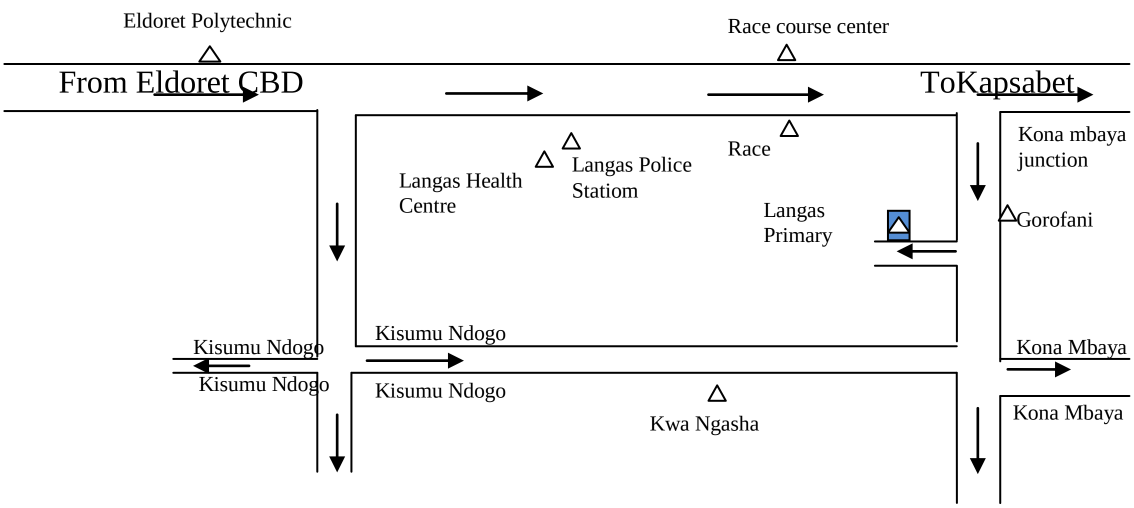


**Fig 3.1: Sketch map of Langas Area Showing the Location of Langas Primary School (Not drawn to scale)**

### 3.2 Study Subjects/Participants

The study population was school children different learning at Langas primary. The participants included both females and males aged 5-16 years. Research has shown that there is general good compliance from children in this kind of research (Montresor *et al.*, 1998).

**3.3 Sample Size Determination**

The sample size was determined using the fisher's formula of sample size determination for single population proportion as used by Mugenda and Mugenda, (1999).

$$n = \frac{z^2\, p\, q}{d^2}$$

Where

n= the desired sample size

z= the standard normal deviate at the required confidence level.

P = the proportion in the target population estimated to have helminthiases.

q= 1-p

d= Margin of error allowed.

p was taken as 0.5 since the proportion of study subjects infected with geohelminthiases was unknown.

At 0.05% confidence level z =1.96,

Therefore

$$n = \frac{1.96^2 (0.5)\,(0.5)}{(0.05)}$$

=384

Since the sampling frame was less than 10,000 (that is, 1600 participants), sample size adjustments were made using the following formula (Mugenda and Mugenda, 1999) nf = n/{1+(n/N)}

nf = the estimate sample size

n= the desired sample size (384).

N= the estimate of the population size.

Substituting in the above formula,

nf= 384/{1+(384/1600)}=309.677

The sample size was 310.

### 3.4 Sampling Procedures and Research Design

Sampling was carried out based on systematic sampling procedure in which the school was the primary unit and classes were the elementary sampling units (Magnani, 1997). Systematic sampling technique was used and the subjects were recruited randomly and proportionate to class size from classes one to eight. In the systematic sampling, every 5th name ("sampling with a skip of 5") from the attendance register of each class was sampled.Sampling was only done among participants with informed consent. The sampling interval was done using the formula:

K= N/n, where

K= sampling interval

N=total population size (1600)

n=sample size (310)

K=1600/310

N=5.161

The study design was cross-sectional. Due to non-response of some parents and/or guardians and school children, a total of 285 school children were included in the study instead of the anticipated 310. Forty pupils of different gender and age were systematically sampled from each class from classes one to eight. Each class comprised of three streams of 80 pupils in each, thus giving a total of 240 pupils per class.

**3.5 Inclusion and Exclusion Criteria of Study Subjects/Participants**

Participants who provided their stool samples and filled the questionnaires were included and those who did not provide their stool samples and those who failed to return the questionnaires were excluded.

**3.6 Data Collection Procedures**

The class teachers from Langas Primary school were recruited to coordinate the study subjects during data collection. The pupils and their teachers were given information on the causes of intestinal geohelminth infections among school- aged children and their parents/guardians were asked to fill a Consent form once convinced that every child ought to be free from such infections.

When Consent forms were filled, the pupils were instructed on the procedure of collecting stool samples by a medical laboratory technologist. One clean wide-mouthed 80ml plastic container, tissue paper and an applicator stick were supplied to each subject to collect a stool sample. The collected samples from the subjects were transported in a coolbox to KEMRI laboratory located at Kisian in Kisumu, refrigerated at $4^0$C and maintained at the same temperature until microscopic examination was done.

### 3.7 Study Variables

The baseline survey involved Subject diagnosis (cross section random sampling) and questionnaire based on three indices: sanitary resources and conditions, personal hygiene and behavioral habits and socio-economic status (Caneiro *et al.,* 2002). The sanitary resources and conditions studied were: availability of toilet and type of toilet, water sources, and home backyard (compound) ground cover and school ground cover. The personal hygiene and behavioral habits studied included: defecation site at night, frequency of deworming, protective footwear, toilet cleanliness, hands washing after defecation, water boiling habits, fruits washing and finger nails cleanliness.

The socio-economic Status of the parents and/or guardians was studied basing on the house type, parenthood (guardian, single or couple parentage), household income, education level of parent/guardian and household assets (having a car, refrigerator, colour TV, black and white TV, DVD recorder and radio)

### 3.8 Data Collection Procedures and Ethical Considerations

#### 3.8.1 Questionnaire- Based Data Collection on Household Income and Assets

The variability of the household's socioeconomic status was determined by the first principal component.Greatest weight was given to households possessing a car, refrigerator and Digital Versatile/Video Disc (DVD) recorder. After standardizing the asset weight variables, households with a car, refrigerator, colour television (TV) and

DVD recorder were scored highest, whereas lowest scores were assigned to households with no refrigerator, no car, no colour TV, no DVD recorder and no radio. The second highest mark was awarded to those having black and white TV and radio. Finally,each participant was grouped into three wealth classes: top (having a car,refrigerator,colour TV and DVD recorder);middle (having black and white TV and radio) and bottom(with no car,no refrigerator,no colour TV,no DVD recorder,no black and white TV and no radio ( Mathys *et al.*,2011).

Most of the formal employees and self-employed workers in the urban informal sector from Langas earn an average of Kenya shillings 15,000 and Kenya shillings 10,000 per month respectively. This constituted 75.4 % (215) of the population sampled. The unemployed 13 (4.6%) lot survive on average earnings of ksh 2,900 derived from casual jobs and goodwill from friends and relatives. Therefore, the low income class comprises 228 households. The remaining 20 % (57) employed in public sector earned an average of ksh.30, 000 per month, therefore belonged to middle income class. Under the new classification by Kenya National Bureau of Statistics as quoted in Daily Business Newspaper (Irungu, 2010) the upper limit of low income band was raised from ksh.10, 000 per month to Ksh.23, 672. Therefore all Kenyans earning between ksh.23,672-119,999 belong to the middle income band (24%) and high income band was raised to ksh 120,000 and above.

### 3.8.2 Ethical Considerations

The head teacher of Langas primary school, municipal education officer, and public health officer and the Secretariat of Institutional Research and Ethics Committee at

School of Medicine, Moi University, were contacted for permission and informed consent obtained the parents/guardians of participants (Appendix II). The participants' anonymity was maintained by use of code numbers and every finding was treated with utmost confidentiality and for the purpose of this research only. The filled questionnaires were kept under key and lock cabinet accessible only to the investigator. Individuals diagnosed positive for intestinal geohelminth infections were treated free of charge with Albendazole (400g a single dose).

### 3.9 Fecal Sample Specimen Processing

All samples were microscopically examined either on the day of their collection or the following day. The formal ether concentration technique was used for concentrating helminthes eggs in stool samples and Stoll's technique for approximating the number of eggs per gram of faeces (Cheesbrough, 2005).

#### 3.9.1 Determination of Positive Cases of Intestinal Geohelimnth Infections

Formol ether concentration technique as described by Cheesbrough (2005) was used for concentrating eggs in stool/fecal samples. Approximately 1gm of faeces was added to about 4 ml of 10% formol water contained in a screw-cap bottle and emulsified using a glass rod. A further 3-4 ml of 10% v/v formol water was added, the bottle capped and the mixture shaken for about 30 seconds.

The mixture was passed through a nylon steel sieve collecting the sieved suspension in a beaker. The suspension was transferred into a centrifuge tube and 3-4 ml of diethyl ether added to dissolve fecal fat. The tube was glass-stoppered and agitated vigorously for about a minute. A tissue paper was wrapped round the top of the tube and the stopper carefully loosened to release the pressure that had built up inside the tube.

The content was centrifuged at a speed of 100 revolutions per minute for 1 minute. The sediments of parasite eggs, larvae and cysts formed at the bottom of tube and faecal debris layer collected in a stratum sandwiched between the ether and formol water. Using applicator stick the layer of fecal debris was loosened from the side of the tube and the tube inverted to discard the ether, faecal debris, and formol water. The sediment remained. The tube was returned to its upright position to allow the fluid from the side to drain to the bottom.

The bottom of the tube was tapped to resuspend and mix the sediment. It was transferred onto a microscope slide using a pipette and covered with a glass cover. A small drop of iodine was run under the glass cover to stain cysts, trophozoites and eggs. It was then examined microscopically for identification of helminthes eggs.

### 3.9.2 Determination of of intensity of Human Intestinal Geoheliminth Infection/Diseaes

Stoll's technique as described by Monica Cheesbrough (2005) was used to determine intensity of intestinal geohelminths among participants. The technique was used for counting helminthes eggs per gram of faeces was used to calculate intensity of infection of each species. In this method, the number of eggs counted on the freshly prepared slide was multiplied by a factor of 100 to obtain eggs per gram of stool.

The intensity of an intestinal geohelminth infestation may be indicated by the concentration of its eggs in faeces.In this study, 3g of faeces were weighed and added to 42ml of water to unformed specimen or an equivalent volume of 0.1m sodium hydroxide to a formed specimen to give a 1 in 15 dilution of faeces. The mixture was stirred using a glass rod the container capped and shaken vigorously.

Using a graduated plastic bulb pipette 0.15ml of the suspension was transferred onto a glass slide and covered with two square cover glasses side by side. The suspension was examined under a microscope to identify and count helminth eggs within the cover glass and any eggs lying outside the cover glass. The number of eggs counted in each preparation was multiplied by 100 to give the number of eggs per gram of faeces.

### 3.9.3 Identification of Intestinal Geohelminth Nematodes Ova

Each type of parasite in the entire stool preparation mounted on the microscope was identified basing on the morphological and structural differences between ova. No differentiation in hookworm infection was made between *Necator americanus* and *Ancylostoma duodenale* infections because morphologically the eggs cannot be differentiated readily in the direct examination of faeces.

The unfertilized ova of *Ascaris lumbricoides* are elongated and the fertilized ones are round or oval in shape (Plates A, B, C, D and E; Appendix V). The unfertilized ova are characterized by irregular mammillated (albuminous) coat (Plate A, B and C; Appendix V) or lack mammillated (decorticated) coat (Plate D; Appendix V). In addition, they a thinner and reduced albumin coat than fertilized ova (Plate B and E; Appendix V).

*Trichuris trichiura* ova were **b**arrel-shaped with colourless protruding polar mucoid plugs and their shell was thick and yellow-brown (Plate F; Appendix V).

Hookworm eggs appeared oval in shape and had very thin shell which appeared as blackline around the ovum (Plate G; Appendix V). The embryo appeared segmented into 2-8 morula cells with clear space between the shell and the embryo.

### 3.9.4 Treatment Positive Cases

The subjects found positive with helminths infection(s) were treated with anti-helmintic drug, Albendazole 400g (single dose), as per the prescription of the clinician from Kenya Medical Research Institute (KEMRI).

### 3.9.5 Data Management and Statistical Analysis

Questionnaires were checked for completeness and coded by the investigator. Data was then entered in a computerized database designed in access. It was later exported to SPSS V.16 for analysis. Descriptive statistics (frequencies and mean ± SD) were generated. Chi-square was used to test for differences in proportions, while kruskal-wallis was used to compare mean rank intensities between more than two groups (after normality tests were done). Multiple binary logistic regression was used to identify significant predictors of helminthes infection controlling for confounders. Results were considered significant at 0.05 alpha level.

# CHAPTER FOUR

## 4.0 Results

### 4.1 Distribution of pupils by Gender and Age-group

Out of the 285 participants, 148 (52.0%) were males and 137 (48%) were females.The distribution of pupils by age groups was as shown in Figure 4.1. The main intestinal geohelminth nematodes found in the stool samples of participants were A*scaris lumbricoides, Trichuris trichuria* and Hookworms. Other parasites that were seen in the stool samples were *Entamoeba histolytica* (cysts), *Chilomastix mesnili* (cysts), *Diphylobothrium latum* (eggs), *Entamoeba coli* (cysts), *Endolimax nana* (cysts) *and Giardia lamblia* (cysts).

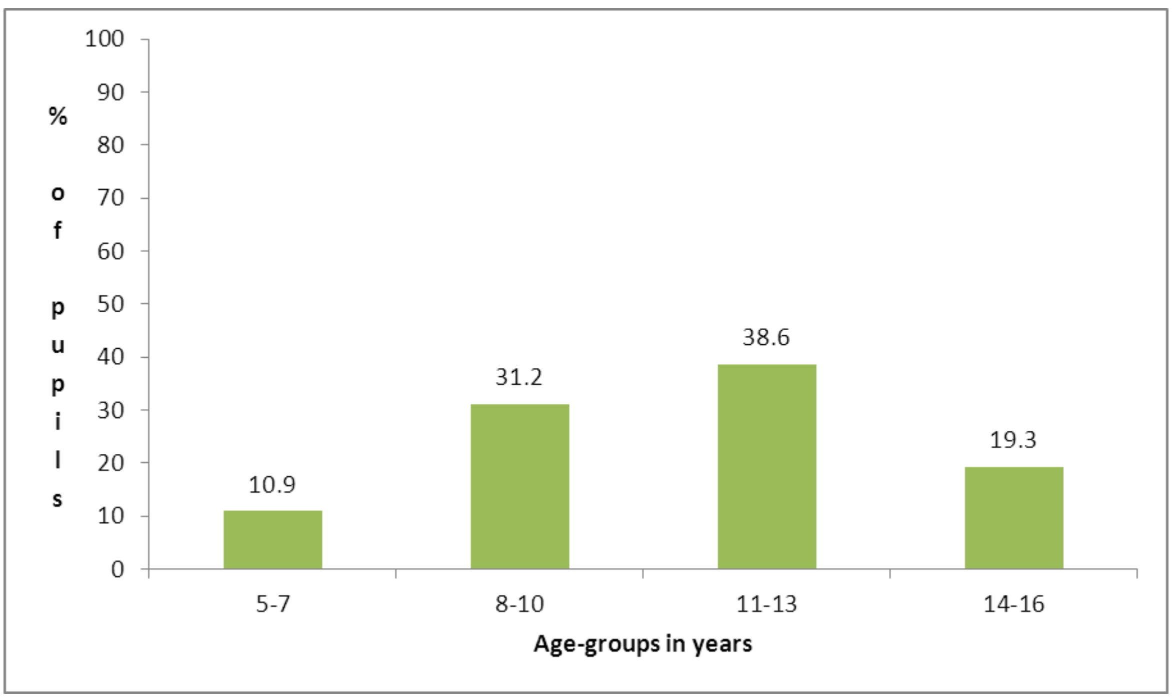

**Fig 4.1: Distribution of pupils by age-group in years**

### 4.2 Prevalence of *ascariasis, trichuriasis* and Hookworm disease

The species prevalences were ascariasis 28.1%, trichuriasis 17.5% and hookworms 10.2% (Figure 4.2). The results indicated that ascariasis was the most prevalent.

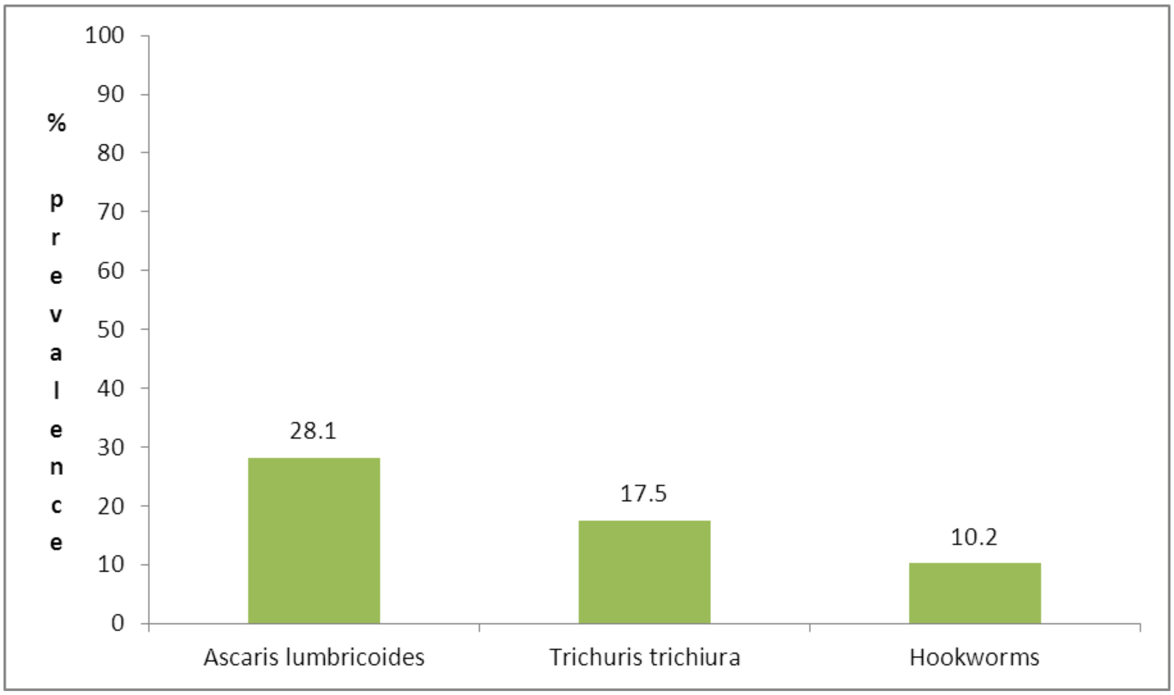


**Fig 4.2: Prevalence of Intestinal Geohelminth Nematodes infection in study Subjects/Participants.**

**4.3 Prevalence of Ascariasis, Trichuriasis and Hookworm Disese by Gender and age-group.**

Of the 148 males examined, 43 (29.1%) had ascariasis, 30 (20.3%) had trichuriasis, and 11(7.4%) had hookworm disease while out of the 137 females examined, 37 (27%) had ascariasis, 20 (14.6%) had trichuriasis and 18 (13.1%) had hookworm disease (Figure 4.3).

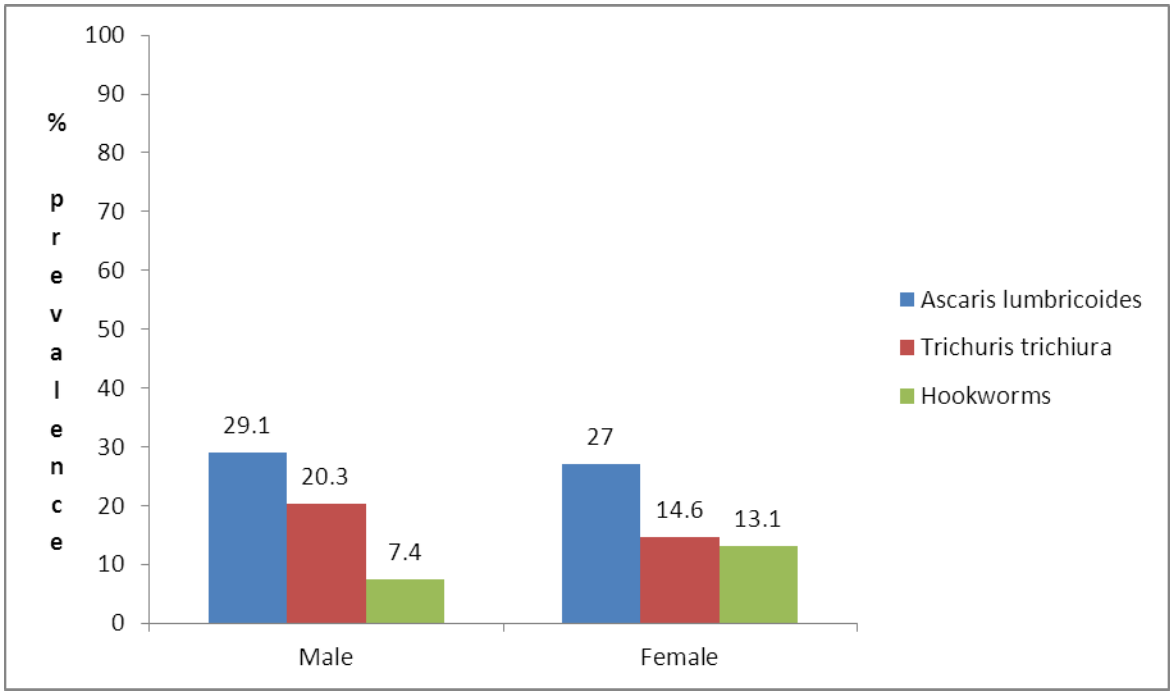


**Fig 4.3: Infection of Intestinal Geohelminth Nematodes by Gender**

**4.4 Intestinal Geohelminth Infections by Age Groups**

Males had the highest prevalence of ascariasis (29.1%) followed by trichuriasis (20.3%) (Figure 4.3). Hookworm's prevalence was high in females (13.1%) in contrast with (7.4%) in males. However, the Pearson chi-square tests showed no significant differences in prevalence between gender for ascariasis, trichuriasis and hookworm disease (p>0.05). Pupils in the age-group 11-13 years old had the highest prevalence of ascariasis (37.3%), trichuriasis (23.6%) and hookworm disease (14.5%) (Figure 4.4).

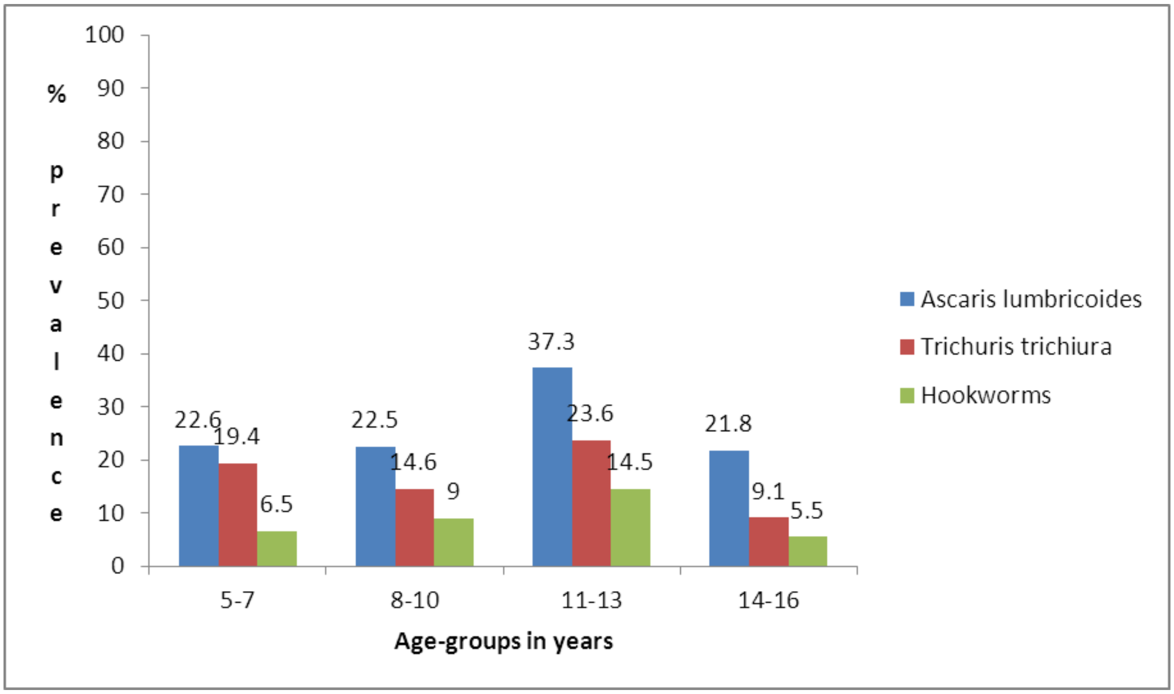


**Fig 4.4: Intestinal Geohelminth Infections by Age-groups.**

### 4.5 Intensities of Intestinal Geohelminth Nematodes infections

The overall specific mean intensities of infection were *Ascaris lumbicoides* 256.32 ±94.90 eggs per gram (epg), *T. trichiura* 102 ± 14.10 epg and hookworm 120.69 ± 77.4. The mean intensities of infection for males was 254.35 ± 106.9 epg for *Ascaris,* 100± 0.0 epg for *Trichuris* and 100 ±0.0 for hookworm. The mean intensity of *Ascaris* infection was the highest in both males 254.35 ±106.8 epg) and females 258.54 ± 80.55 epg) and the lowest for both *Trichuris* (100 ±0.0 epg) and hookworm (100 ±0.0 epg) (Table 4.1).

**Table 4.1: Mean intensities (eggs/gram of stool) of soil transmitted intestinal nematodes infection by gender and age.**

| | Eggs/gram of stool(epg) | | | | | |
|---|---|---|---|---|---|---|
| **Parasite species** | *Ascaris lumbricoides* | | | *Trichuris trichiura* | | Hookworm |
| **Gender** | | | | | | |
| Male | 46 | 254.35±106.9 | 30 | 100 ± 0 | 11 | 100 ± 0 |
| Female | 41 | 258.54 ± 80.5 | 20 | 105 ± 22.4 | 18 | 133.33±97.0 |
| **Age** | | | | | | |
| 5-7 | 7 | 142.86±113.4 | 6 | 100± 0 | 2 | 100± 0 |
| 8-10 | 20 | 200 ±32.4 | 13 | 100±0 | 8 | 175.0±138.9 |
| 11-13 | 47 | 270.21 ± 72 | 26 | 103.85±19.6 | 16 | 100± 0 |
| 14-16 | 13 | 353.85±112.7 | 5 | 100±0 | 3 | 100±0 |

### 4.6 Multiparasitism

Out of the 159 (15.26%) positive subjects, 88 (55.4%) had single infections and 71 (44.7%) had multiple infections. Out of the 7 (44.7%) subjects with multiple infections, 39 (54.9%) had double infections with ascariasis and trichuriasis, 20 (28.2%) had double infections with ascariasis and hookworm disease, 6 (8.5%) had double infections with trichuriasis and hookworm and 6 (8.5%) had triple infections with ascariasis, trichuriasis and hookworm disease.

Among the 34/84(40.5%) males with multiple infections, the highest multiparasitism was double infection with ascariasis and trichuriasis in males 23 (67.6%). Similarly among the 37/75 (49.3%) females with polyparasitism, the highest prevalence for polyparasitism was double infection with ascariasis and trichuriasis, 16 (43.2%), and in the age group of 11-13 years old, 20 (10%) (Table 4.2).

**Table 4.2: Multiple infections of soil transmitted intestinal nematodes by gender and age**

| **Parasite species** | *Ascaris* +*Trichuris* | *Ascaris* +hookworms | *Trichuris* +hookworms | *Ascaris* +*Trichuris* +hookworm |
|---|---|---|---|---|
| **Gender** | | | | |
| Male | 23 (67.6%) | 7 (20.6%) | 2 (5.9%) | 2 (5.9%) |
| Female | 16 (43.2%) | 13 (35.1%) | 4 (10.8%) | 4 (10.8%) |
| **Age-group in years** | | | | |
| 5-7 | | | | |
| 8-10 | 6 (19.4%) | 1(3.2%) | 1(3.2%) | 1 (3.2%) |
| 11-13 | 8 (9.0%) | 5 (5.6%) | 1(1.1%) | 1 (1.1%) |
| 14-16 | 20 (18.2%) | 11 (10.0%) | 4 (3.6%) | 4 (3.6%) |
| | 5 (9.1%) | 3 (5.5%) | 0 (0%) | 0 (0%) |

### 4.7 Sanitary Resources and Conditions

#### 4.7.1 Toilet Availability, Use and Maintenance

All the subjects responded that they had access to a toilet. The percentage of school children who used communal pit latrines (Plate J; Appendix VI) was 53.7 % (153), users of indoor toilet (Plate H; Appendix VI) were 24.4% (61) and household toilets (Plate I; Appendix VI) was 24.9 % (71) respectively.

The infection with the three species of helminthes was highest in children with communal pit latrine, followed by users of household pit latrines and lowest in those with indoor house toilet (Tables 4.3, 4.4 and 4.5; Appendix XI**)**. The users of communal pit latrine had 58 (37.9%) ascariasis, 36 (23.5%) trichuriasis infection and 18 (11.8%) hookworm disease. The subjects who utilize inside house toilet for defecation 61(24.4%) had significantly low ascariasis, 3 (4.9%), trichuriasis 2 (3.3%) and 2 (3.3%) hookworm disease (Table 4.5; Appendix XI). The Pearson chi-square tests exhibited significant differences between toilet type and prevalence of ascariasis and trichuriasis ($p<0.001$).

### 4.7.2 Home Backyard (Compound) Ground Cover and School Ground Cover

The distribution of backyard home ground cover environment was 110 (38.60%) bare ground, 131 (45.96) grass covered and 44 (15.44%) concrete (Plates K, L, M and N; Appendix XII). The highest infection rates with intestinal geohelminth nematodes were among the school children living in homes with bare ground compound which registered 53 (48.2%) ascariasis infection, 31 (28.2%) trichuriasis and 19 (17.3%) hookworm disease.

The subjects residing in homes with concrete background ground cover had the lowest infection rates of 1(2.3%) for both ascariasis and trichuriasis infections and significantly no hookworm disease (Tables 4.3 and 4.4; Appendix XI). Concrete background is commonly found in brick or cement block wall enclosed permanent houses where the yards are concrete to avoid muddy compounds. Backyard school environment had bare ground (Plate L; Appendix VII) from the gate up to the assembly region, a quarter of the play ground and the surrounding of latrines. There was also a broken sewage line near the school gate, adjacent the fence (Plate O; Appendix VII). The Pearson chi-square tests showed significant correlation between background home environment and prevalence of ascariasis and trichuriasis but not with hookworm disease ($p<0.05$).

### 4.7.3 Water Sources, Contamination and Maintenance

The sources of water for drinking, bathing and washing were 56 (19.65%) borehole, 147 (51.58%) communal piped water and 82 (28.77%) household piped water (Plates P, Q, R, S, T, U, V and W; Appendix VIII). The subjects who relied on borehole water had the highest prevalence of ascariasis at 28 (50%) followed by trichuriasis at 23 (41.1%) and the least was hookworm disease at 10 (17.9%). Among the subjects who relied on borehole water, the infection rate was highest in children whose homes had wood covered, 31 (10.88%) and 20 (7.02%) iron sheet covered boreholes. The least prevalence was recorded among the participants who relied on concrete covered boreholes 11(3.86%).

The prevalence of helminthes infections for the participants relying on wood covered borehole was 17 (54.8%) ascariasis, 12 (38.7%) trichuriasis and 7(22.6%) hookworm disease and those relying on iron sheet covered boreholes had 10 (50%) ascariasis, 8 (40%) trichuriasis and 4 (20%) hookworm disease. Amongst the subjects drinking piped water, highest intestinal geohelminths infection was detected in those taking communal piped water at prevalence of 39 (26.5%), 21(14.3%) and 11(7.5%) with ascariasis, trichuriasis and hookworm disease respectively. Generally the lowest prevalence of intestinal geohelminths was amongst the school children who utilized household piped water. Household piped water is located inside the houses and communal piped water is situated at various locations within the community at isolated points and also in the compounds of rented houses where it's shared amongst the community.

### 4.8 Impact of Personal Hygiene and Behavioral Habits on Prevalence of Geohelminths Nematodes

#### 4.8.1 Defecation Site at Night

A majority of participants 227(79.65%) always use a toilet for defecation at night compared to 26 (9.12%), 25 (8.77%) and 7 (2.46%) who utilized the field, garden and drenches respectively as their defecation sites at night. The highest infection rate with ascariasis occurred amongst school children defecating in drenches, 6 (85.7%) followed by the users of garden14 (56.0%) and field 14 (53.8%) respectively.

The infection rates with trichiuriasis are almost similar for subjects that used the field, 12(46.2%) and garden, 12(48%). The prevalence of hookworm infection was approximately the same for field users 5 (19.2%) and garden users 6 (24%). The Pearson chi-square tests exhibited significant differences between defecation site at night and prevalence of ascariasis and trichiuriasis. The statistical difference between the users of drenches and hookworm infection was insignificant (Tables 4.3 and 4.4; Appendix XI).

#### 4.8.2 Toilet Cleanliness

Of the 285 subjects sampled, 82(28.77%) never cleaned toilet, 4 (1.4 %) sometimes cleaned and 199 (69.82 %) always cleaned toilet.Toilets are sometimes cleaned, always cleaned and others never cleaned (Plates X and AA; Appendix IX). Out of the participants who never cleaned toilets at home, 44 (53.7%) were positive for ascariasis, 26 (31.7%) were positive for trichiuriasis and 12 (14.6%) were positive for hookworm disease. The school children who responded to always cleaning toilets at home had prevalence of 34 (17.1%) ascariasis, 24(92.1%) trichiuriasis and 16 (8.0%) hookworm disease. The highest infection was recorded among the subjects who never cleaned toilets at home, followed by those who always washed their toilets (Tables 4.3, 4.4 and 4.5; Appendix XI).

### 4.8.3 Hand Washing After Defecation

From a total of 285 subjects sampled, 160 (22.5 %) responded that they never washed their hands after defecation, 54 (42.6 %) indicated that they sometimes washed hands and 71(29.6%) said that always washed hands. Out of the participants who never washed hands 36 (22.5%) were positive for ascariasis, 22 (13.8%) were positive for trichuriasis and 13 (8.1%) were positive for hookworm disease. The highest prevalence for the parasites was observed in those subjects who sometimes washed their hands followed by those who never washed their hands after defecation (Plates 4.3, 4.4 and 4.5; Appendix XI).

### 4.8.4 Water Boiling Habits

Of the children investigated, 87 (30.53%) responded that their households never boil water for drinking, 86 (30.53%) sometimes boil water and 112 (39.30%) always boil water. A large proportion of those who never boil water 36(41.4%) had *Ascaris* infections followed by those who sometimes boil water (26.32.6%). The school children who always boil water had the least infection rate of 16(14.3%) ascariasis, 11 (9.8%) trichuriasis and 7 (6.2%) hookworm disease.

The subjects who sometimes boiled water 86(30.52%) showed prevalence of 28(32.6%) ascariasis, 21 (24.4%) trichiuriasis and 11(12.8%) hookworm disease (Tables 4.3, 4.4 and 4.5; Appendix XI). There was significant correlation between water boiling and the prevalence of ascariasis, trichuriasis and hookworm disease.

### 4.8.5 Fruits and Vegetables Washing

It was observed in the study population that 43 (15.09 %) never washed fruits and vegetables before eating, 139 (48.77 %) sometimes washed and 103 (36.14 %) always washed. The infection rates were highest among the subjects who never washed fruits and vegetable before eating followed by the group that sometimes washed.

The prevalence for those who never washed fruits and vegetables before eating was 23 (53.5%) ascariasis, 18 (41.9%) trichuriasis and 9 (20.9%) hookworm disease. The prevalence of helminthes infection for those who sometimes washed was 53 (38.1%) ascariasis, 30 (21.6%) trichuriasis and 16 (11.5%) hookworm diease. The lowest prevalence of intestinal geohelminth nematodes was detected among those who always washed fruits and vegetables.

### 4.8.6 Finger Nails Cutting

An investigation in the habit of cutting long finger nails showed that out of 285 sbjects, 4(1.40%) never cut their finger nails at all, 131 (45.96 %) sometimes cut and 150 (52.63 %) always cut their finger nails. There were 4 (100%) ascariasis and 2(50%) trichuriasis among those that never cut their finger nails. It is significant to note that there were no hookworm infections among those who never cut their fingernails. The second in rank were those who sometimes cut finger nails at infection rates of 60 (45.8%) ascariasis, 38 (29%) trichuriasis and 22 (16.8%) hookworm disease. There was low prevalence by ascariasis, trichuriasis and hookworm disease for those who always cut finger nails (Tables 4.3, 4.4 and 4.5; Appendix XI).

### 4.8.7 Protective Footwear

Of the 285 subjects, those who never wore shoes showed the highest prevalences of intestinal geohelminth infections with hookworm disease 110 (38.1%), trichuriasis 29 (33.3%) and 81 (28.0%) ascariasis. The infections were lowest among the subjects that always wore shoes with prevalences of ascariasis 40 (14.3%), trichuriasis 24 (8.3%) and 1 (0.4%) hookworm disease.

### 4.8.8 Frequency of Deworming

Out the 285 participants, those who had never been dewormed showed the highest prevalence of ascariasis at 28 (96.6%), trichuriasis 18 (62.1%) and hookworm disease 6 (20.7%) followed by those who were sometimes dewormed (Tables 4.3, 4.4 and 4.5; Appendix XI). There was no infection by the three species of parasites in the subjects who were always dewormed. The infection rate was lowest in persons who were dewormed in less than 1 year and 1-2 years before the study and highest in pupils who had not been dewormed for the last 3-4 years and above, and those who had never been dewormed at all.

### 4.9 Impact of Socio-Economic Factors on Prevalence of Human Intestinal Geohelimnth Infections

The socio-economic status was evaluated in regard to house type, education level, parenthood, house hold income and household assets. The household assets included having a car, refrigerator, colour TV, black and white TV, radio and DVD recorder.

#### 4.9.1 House Type

Out of the 285 participants, 120 (42.11%) lived in concrete walled houses, 36 (12.63 %) lived in mud walled with earth floor houses; 34 (11.93 %) lived in wooden with cement floor houses; 87 (30.53 %) lived in mud walled with cement floored houses and 8 (2.81 %) lived in wooden houses with earth floor (Plates AB, AC, AD, AE and AF; Appendix X). The highest prevalence of intestinal helminthes was amongst the subjects who resided in wooden houses with earth floor followed by the subjects who lived in mud wall with earth floor and wooden houses with cement floor. The lowest infection was amongst the participants who resided in concrete houses (Table 4.3, 4.4 and 4.5; Appendix XI).

In wooden earth floored houses, the infection rate was 6 (75%) ascariasis, 4 (50%) trichuriasis and (25%) hookworm disease. The residents of mud walled with earth floor and wooden wall with cement floor houses had close infectivity of 18(50%) and 18

(52.9%) ascariasis; 14(38.9%) and 9 (26.8%) trichuriasis, and 6 (16.7%) and 6 (17.6%) hookworm disease respectively. The subjects in mud wall with cement floor, ranked second last with prevalence of 22 (25.3%) ascariasis, 16 (18.4%) trichuriasis and 12 (13.8%) hookworm disease (Table 4.3, 4.4 and 4.5; Appendix XI). The lowest infection was amongst the residents of concrete walled houses, where prevalence was 16 (13.3%) ascariasis, 7 (5.8%) trichuriasis and 3 (2.5%) hookworm disease (Table 4.3, 4.4 and 4.5; Appendix XI).

### 4.9.2 Level of Education of Parents/Guardian

The investigation into the level of education of parents or guardians showed that out of 285 subjects, 18 (6.31 %) were without formal education, 105 (36.84 %) had primary education, 122 (42.81 %) had secondary education and 40 (14.03 %) had tertiary education. The highest prevalence of helminthes was registered in children whose parents or guardians were without formal education, followed by those whose parents or guardians attained primary school education. The lowest infection was in school children whose parents or guardians attained tertiary education.

### 4.9.3 Parenthood, Household Assets and Household Income

School children with single parents 102 (35.79 %) had the highest prevalence of ascariasis 35 (34.3%), trichuriasis 27 (26.5%) and hookworm disease 10 (9.8%). Children living with both parents and those living with guardians had more or less the same prevalence of intestinal geohelminth nematodes.

The results exhibited highest prevalence of ascariasis in children who belonged to bottom class, followed by those in the middle class and those children in the top class (Figure 4.5). Of the 138 children in the bottom class 37.4% had ascariasis, 29.4% had trichuriasis and 13% had hookworm disease. Out of the 125 children in the middle class 31.6% had ascariasis, 23.2% had trichuriasis and 14.4% had hookworm disease. Of the 22 children in the top class 7.1% had ascariasis, 9.1% had trichuriasis and 4.5% had hookworm disease.

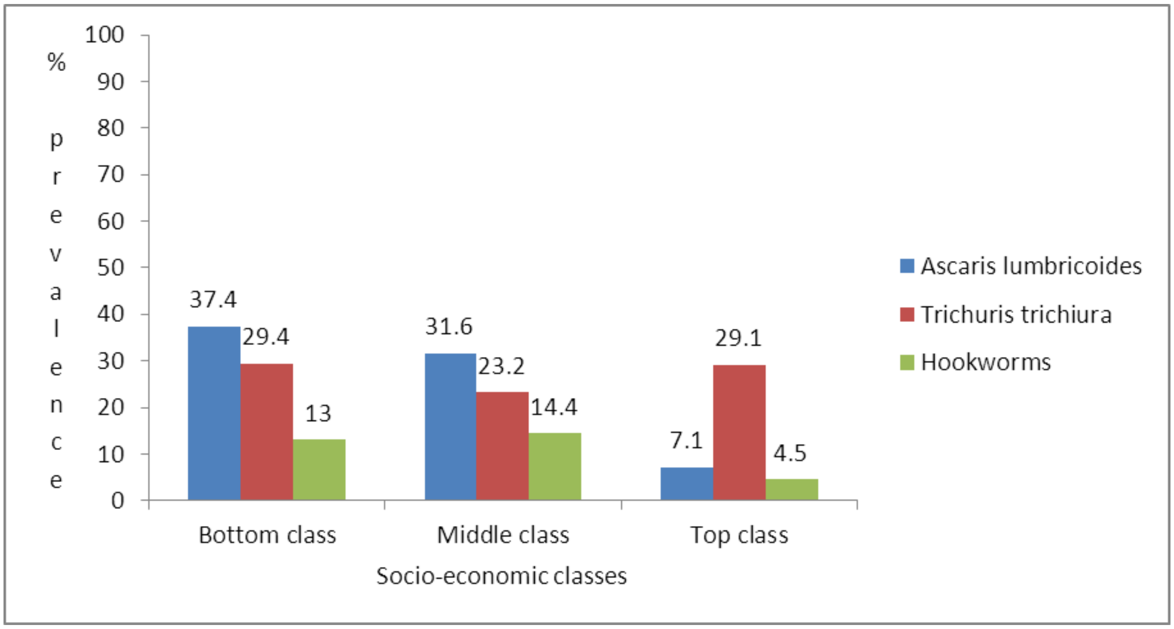


**Fig 4.5: Prevalence of Intestinal Geohelminth Nematodes by Soci-economic Classes**

The results indicated that out of 285 children who participated in the study are either parents and/or guardians of low income earners or middle income earners (Figure 4.6). The prevalence of intestinal geohelminth nematodes infection in low income category was 14 (58.3%) ascariasis, 13 (54.2%) trichuriasis and 7 (29.2%) hookworm disease.

Amongst the medium income households, the prevalence was 66 (25.4%) ascariasis, 37 (14.2%) trichuriasis and 22 (8.5%) hookworm disease (Figure 4.6).

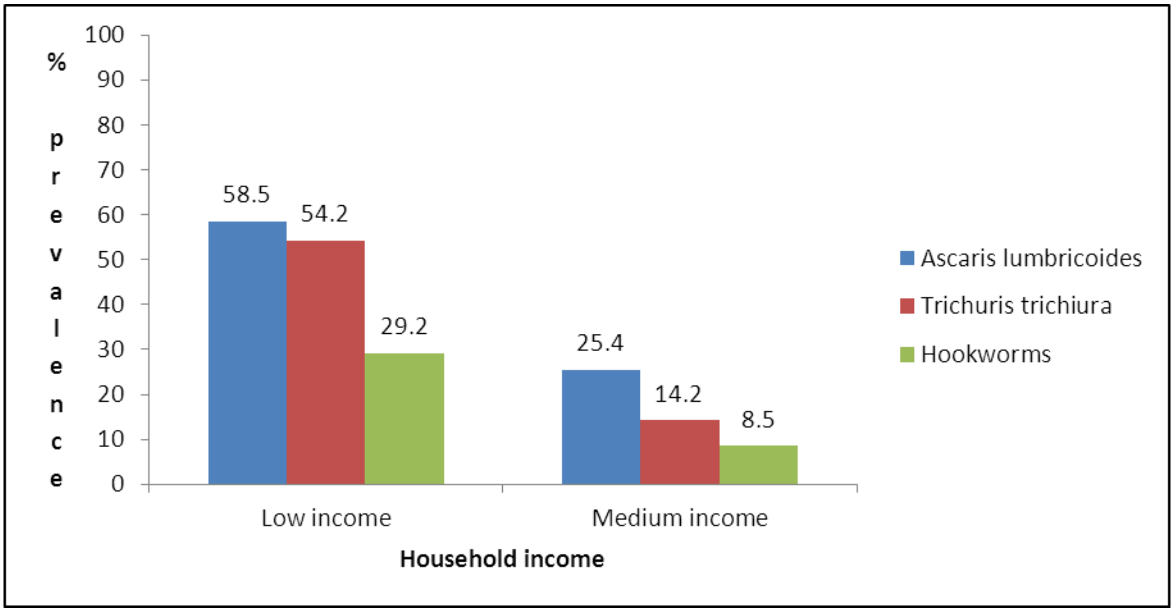


**Fig 4.6: Prevalence of Intestinal Geohelminth Nematodes by Income**

## 4.10 Prevalence and Intensity of Intestinal Geohelminth Nematodes Infections/Diseases

As indicated in Table 4.3; Appendix XI, among the sanitary resources and their nature, water source, toilet type, backyard home ground cover environment and nature of borehole were significantly and independently associated with human ascariasis ($p<0.05$). Similarly among the personal hygiene and behavioral habits, hand washing after defecation, fruit washing, frequency of deworming, finger nail cutting and water boiling were significantly and independently associated with ascariasis ($p<0.05$). House type, household income and parent/guardian education level were the socio-economic factors significantly associated with ascariasis ($p<0.05$).

As in Table 4.4; Appendix XI, among the sanitary resources and their nature, water source, toilet type, backyard home environment, and nature of borehole were significantly independently associated with trichuriasis ($p<0.05$). Similarly among the personal hygiene and behavioral habits, fruit washing, frequency of deworming, finger nail cutting and water boiling were significantly independently associated with trichuriasis ($p<0.05$). House type, household income and parent/guardian education level were the socio-economic factors significantly associated with trichuriasis ($p<0.05$). As indicated in Table 4.5; Appendix XI, among the sanitary resources and their nature backyard home ground cover environment, and nature of borehole were significantly and independently associated with hookworm disease ($p<0.05$). Similarly among the personal hygiene and behavioral habits, shoe wearing, fruit washing, frequency of deworming and finger nail cutting were significantly and independently associated with Hookworm disease ($p<0.05$). House type, household income and parent/guardian education level were the socio-economic factors significantly associated with hookworm disease ($p<0.05$).

Fruit washing was a significant factor associated with ascariasis ($p<0.05$). Those who never and those who sometimes wash fruits were more likely to suffer from ascariasis as compared to those who always wash fruits (Table 4.3; Appendix XI). Similarly controlling for all other factors, fruit washing and defecation site at night were significant factors associated with trichuriasis ($p<0.05$). Those who never and those who sometimes wash fruits were more likely to suffer from trichuriasis as compared to those who always wash fruits (Table 4.4; Appendix Xi). Those whose defecation site at night were field, garden or drench were more likely to have trichuriasis as compared to those whose defecation site at night was toilet (Table 4.4; Appendix XI). This was also similar with hook worm infection (Table 4.5; Appendix XI).

# CHAPTER FIVE

## 5.0 Discussion, Conclusion and Recommendation

## 5.1 Discussion

### 5.1.1 Prevalence of *Ascariasis, Trichuriasis* and Hookworm Disease.

The study showed that prevalence of helminth infection among primary school children was highest with ascariasis followed by trichuriasis and lowest with hookworm disease. These findings correlate the study carried out in the City of Nairobi (Mwanthi *et al*., 2008). The highest prevalence of ascariasis and trichuriasis in this study was recorded in males which was comparable to previous works (Albonico *et al.,* 1999; Ukpai *et al.,* 2003; Dakul *et al.,* 2004; Mwanthi *et al.,* 2008; Uneke *et al.,* 2009) but contrary to others (Flores *et al.,* 2001; Odikamnoro *et al.,* 2004).

The prevalence was probably due to exposure to the same unsanitary conditions at school particularly the sewerage sludge near the school gate (Plate O; Appendix VII) and almost the same personal unhygiene and unsanitary behavioural habits among the pupils. Generally, this pattern of infection in the school children was related to the fact that human ascariasis, trichuriasis and hookworm disease in urban slums were spread through faecal pollution of soil, and so the intensity of infections depends on the degree of soil pollution to which a majority of school-age children were exposed (Maipanich *et al.,* 1995; Gyoten *et al*., 2010).

Hookworm disease was higher in females in contrast to other studies which reported higher infection among the male subjects (Gunawardena *et al.,* 2005). The differences between the prevalence of intestinal geohelminth infection by gender could be gender dependent and related to the levels of exposure. This was apparently the case with female school children who fetched water for drinking, washing clothes and other domestic purposes from boreholes and water points with moist, dump surroundings suitable for hookworm survival (Plates P, R,S and T; Appendix VIII). Therefore, they are most likely exposed to hookworm contaminated soil compared to males. Furthermore, female school children probably pluck vegetables from gardens which are contaminated with infected feacal matter. The duty of a female child and /or woman harvesting vegetables in a garden is in line with African tradition particularly in rural Kenya.

The prevalence of ascariasis was higher than that of trichuriasis and hookworm disease in the study subjects. This was consistent with previous reports from Nigeria (Adeyeba and Akinlabi, 2002) and Kenya (Mwanthi *et al*., 2008). The high prevalence of ascariasis was attributed to the adhesiveness of their eggs which readily stick to many objects/items such as door handles, dust, fruits and vegetables, paper money and coins (Kagei, 1983; Crompton, 1989) and even exercise books, textbooks, pencils and pens which are usually used and/or shared by children in public schools.

The subjects in the age bracket 11-13 years had the highest prevalence of ascariasis, trichuriasis and hookworm disease. These results are in line with Uneke *et al*. (2009) and Ezeagwuna *et al.* (2010) who observed higher prevalence rates among the age groups 11-12 and 11-13 years respectively. Dada- Adegbola *et al*. (2005) also reported prevalence of 81.6%, 63.3% and 52.4% among children aged 12-17 years, 6-11 years and less than 5 years respectively. These findings were contrary to the data from the City of Nairobi which indicated that the age bracket 14-16 years had the highest prevalence of ascariasis, while 11-13 age brackets had the highest prevalence of trichuriasis (Mwanthi *et al.*, 2008). The high infectivity in this age group could be attributed to infrequent deworming by parents, particularly mothers whose attention on health status of children shift to the younger ones aged below 11 years.

The observation for high trichuriasis in the age group 11-13 years and gender was consistent with related studies (Albonico *et al.*, 1999; Ukpai and Ugwu 2003; Dakul *et al.*, 2004; Uneke *et al.*, 2009) but contrary to other reports which indicated that females have higher infections than males in this age stratum (Flores *et al.*, 2001; Odikamnoro and Ikeh, 2000; Ekpenyong *et al.*, 2008). The high prevalence of hookworm infection in the ages 11-13 years confirms the reports of Crompton 2002, and Ekpenyong *et al.* (2008) but contrary to that of Mwanthi *et al.*, (2008) which reported the highest prevalence in the age group 14-16 years. These reports also attributed higher prevalence of hookworm infections in older children to changes in behavior as one gets older (Crompton, 2002). This was probably in line with the host response to hookworm infection. Research has shown that protective immunity does not seem to develop in human hosts, so infections occur in all age groups depending on exposure patterns and tend to be prolonged (Crompton, 2002). As a result, infectivity intensifies with increase in age especially in endemic areas.

In this investigation, the exposing behaviour included play habits with soils (Kurup and Gurdip, 2010) in the backyard home ground environment and school fields which are dusty during drought and muddy during rain seasons (Plates K and L; Appendix VII) and were apparently contaminated with intestinal geohlminth eggs from egg laden sludge from broken sewerage pipe next to the school (Plate O; Appendix VII).

### 5.1.2 Intensities of Intestinal Geohelminth Nematodes Infections

The mean intensity of ascariasis was high followed by hookworm and then trichuriasis. The values were surprisingly low given the high prevalence of the parasites and the urban slum environment where the subjects reside. However, in several other studies high prevalence was associated with low mean intensities.

The high mean intensity of ascariasis observed in males and females was probably due to domestic and behavioral activities that exposed them to contact with soils contaminated with egg laden fecal matter (Ekpenyong *et al.,* 2008). The highest mean intensity of hookworm was recorded in the age 14-16 years. This coincided with other findings that intensity of hookworm infection is high in this age group (Uneke *et al*., 2009 and Crompton, 2002). This was the age group that played ball games in muddy fields (Plate L; Appendix VII), drew water for domestic use obtained from boreholes and communal pipes with ambient damp grounds (Plates P, R and S; Appendix VIII) and also probably involved in moulting soft mud and cowdung for smoothening the floor and making walls for mud walled houses (Plate AB; Appendix X).

### 5.1.3 Multiparasitism

Mixed infections were common with ascariasis and trichuriasis in both males and females and in all age groups. This was because the conditions which influence the presence of ascariasis in a population also influence the presence of trichuriasis (O'larcain and Holland, 2000). As a result, these two species of helminthes are often found in association in human communities (Crompton, 1994; Brooker *et al.,* 2000).

In contrast, there was independent transmission of hookworm disease with the other two species. This was because hookworm infection, except anylostomiasis, occurs when its larvae penetrate the skin of the human host. As for ascariasis and trichuriasis, transmission occurs when their ova are swallowed by the host. Therefore in this research this phenomenon was not unexpected given the similarity of mode of transmission and epidemiology of *Ascaris lumbricoides* and *Trichuris trichura* and dissimilarity in transmission and epidemiology of hookworm (Brooker *et al.,* 2000).

These findings confirm that many children in primary school (44.7 %) harbor more than one helminthes species. This was consistent with observations made by other workers on poly parasitism in Kenya (Brooker *et al.,* 2000). Brooker *et al.,* 2000 found that subjects with multiple species infections had a higher egg count of each intestinal geohelminth nematode species than the subjects with single species infection. School children with multiple species infections generally carry heavier infections of each species than school children carrying single species infections (Brooker *et al.,* 2000) and may also suffer multiple morbidity due to each species infection (Brooker *et al.*, 2000; Kvalsvig *et al.,* 1991). The school children with multiple species infections may suffer simultaneously from each species disease like ascariasis, trichuriasis and hookworm disease and as a result, they would experience multiple morbidity associated with each species of intestinal geohlminth infection (Brooker *et al.,* 2000). The multiple species infections were probably due to a series of mechanisms evolved by parasites to evade the host defense strategies (Brooker *et al.,* 2000).

Multiparasitism could be due to the fact that most school children share common attributes mainly poor personal hygiene and behavioral habits ,poor sanitary resources and low socio-economic status. According to Uneke *et al.* (2009), multiparasitism is probably related to poor sanitary conditions or contaminated water supplies and a more soil rich urban or semi-urban environment where the parasites successfully complete their life cycles.

### 5.1.4 Prevalence and Intensities of Intestinal Geohelminth Nematodes Infection/Disease

Factors enhancing exposure to helminthiases have been implicated in previous field studies to include defecation practices ( Hadidjaja *et al.,*1998; Gunawardena *et al*.,2004; Anantaphruti *et al.,* 2004; Gunawardena *et al.,* 2005; Uneke *et al.,* 2009), cultural differences relating to personal and food hygiene (Coelho *et al*., 2001; Anantaphruti *et al.,* 2004; Gunawardena *et al.,* 2005; Avcioglu *et al.,* 2011), occupational necessities (Gunawardena *et al.,* 2004) and housing conditions (Holland *et al.,* 1988; Gunawardena *et al.,* 2004). Each of the above factors can be compounded by socio-economic status, with the poorest having the most worm burden (Holland *et al.*, 1988; Gunawardena *et al.*, 2004).

#### 5.1.4.1 Sanitary Resources and Conditions

##### 5.1.4.1.1. Toilet Availability, Use and Maintenance

All the children reported to have toilets at home. The users of communal pit latrine (Plate J; Appendix VI) had the highest ascariasis infection (37.9%) followed by trichiuriasis infection and the least was hookworm infection. Research established that in the urban slums of Eldoret Municipality, 96% of the residents used communal pit latrines and over 40% share one pit facility among 6 to 10 households facility (Cheserek and Opata, 2011) and a situation that was associated with higher prevalence of intestinal geohelminth infection (Uneke *et al.*, 2009). This indicated congestion in the use of communal pit latrines that would lead to unsanitary defecation habits like disposal of faeces on the floor of toilets (Plate X and AA; Appendix IX) which was conducive to transmission of intestinal geohelminth nematodes (Sorensen *et al.*, 1997; Cheserek and Opata, 2011). In addition, some communal latrines were adjacent to vegetable gardens (Plate J; Appendix VI and Plate M; Appendix VII) which would readily be contaminated by feacal matter from the latrines, particularly due to‘splashing’method of latrine cleaning and overflow during rains. The vegetables grown next to toilets are likely to be contaminated with helminthes eggs and enhance transmission when they are eaten raw or poorly washed before cooking. Furthermore, the garden owners are likely to carry egg laden feacal matter on their footwear when they harvest the vegetables for food. The heminths eggs carried in their footwear may find the way to the water points, compound yards and houses.

The subjects who utilized indoor toilets for defecation (24.4%) had significantly low infections of ascariasis, trichuriasis, and hookworm disease. This was probably because it was easy to maintain cleanliness of such toilets since there were no incidences of disposing fecal matter on the floor of the toilet due to high sanitary practices associated with their use. It also reduces the chances of environmental contamination particularly of soil, vegetables and water sources.

The subjects who used household pit latrines maintained good sanitary measures due to individual commitment to maintain cleanliness compared to the users of communal pit latrines with minimal communal responsibility. The infection of users of household pit latrine could be attributed to their exposure to untidy and moist conditions caused by deliberate dumping of refuse, mainly perianal materials, and splashed water flow into the surrounding of toilets (Plates Z and AA; Appendix IX).

**5.1.4.1.2 Home Backyard (compound) Ground Cover and School Ground Cover**

The highest infection with ascariasis was registered in the subjects with bare ground backyards at their homes (Plates K; Appendix VII). This was probably due to the presence of *A.lumbricoides* eggs in exposed soils which sometimes become muddy during the rainy season or dusty during drought (Ergelbrecht and Berendt, 1991; Gunawardena *et al.*, 2005).

The exposed muddy soils in the home backyard environment of the subjects and school environment was conducive for survival and transmission of ascariasis and trichuriasis (Ergelbrecht and Berendt, 1991). Bare backyard environment of their homes was a replica of the school environment which was bare from the gate up to the classroom, assembly region, a quarter of play ground (Plate L; Appendix VII) and the area surrounding the latrines. These grounds become muddy during the rainy season, a condition that enhances transfer of feaces in mud on footwears into their classrooms and houses.

In addition there was a heap of sludge from broken sewage line next to the school fence near the gate. This was significant given that egg-ladden fecal matter from broken sewer could be a source from which intestinal geohelminth eggs could be transported by water surface run-off into the school backyard environment. Transmission of eggs from contaminated environment to school children could readily occur through their contact with eggs in the mud, dust or objects during their play at games time (Maipanich *et al.*, 1995). Furthermore, the feacal sludge could attract houseflies and cockroaches which often carry high numbers of intestinal geohelminth eggs (Humayun *et al.*, 2002) mechanically transporting them to the desks, books, pens, pencils, food (Drangert *et al.*, 2010) and various objects and surfaces that school children were likely to come into contact with .

The school children with concrete covered yards (Plate N; Appendix VII) had low *Ascaris* and hookworm infections. The low ascariasis was attributed to the ease of cleaning a concrete ground in which eggs could otherwise stick and thrive. The low hookworm disease was particularly important given that hookworm infection occurs in moist soils and dampy areas from where the larvae survive longer to penetrate the human skin of the host human (Gunawardena *et al.*, 2005).

**5.1.4.1.3 Water Sources, Contamination and Maintenance**

The source of water for drinking had significant bearing on infection of the parasites. The children whose source of drinking water was wood covered boreholes (Plate R; Appendix VIII) and iron sheet covered boreholes had the highest infection with ascariasis and trichuriasis. This was probably due to fecal contaminants from the surrounding which found way into the porous boreholes (Plates R, and T; Appendix VIII) during rainy season and through dust during dry season (Maipanich *et al.*, 1995). It was also due to the moist surrounding of water points (Plates P, R, S, and T; Appendix VIII) favorable for the survival of intestinal geohelminth eggs and larvae (Gunawardena *et al.*, 2005).

In addition the boreholes are sunk in unhealthy environments such as between households or near sewerage lines (Plate U; Appendix VIII). This resulted in the contamination of water sources by seepage of sewerage containing helminthes eggs into the boreholes (Cheserek and Opata, 2011). There was also evidence that washing of clothes and probably bathing occurred at sites of some boreholes which contributed to water contamination (Plate R; Appendix VIII). The low income parents and/or guardians who could not pay for clean water from the Municipal Water Kiosks (Plate V; Appendix VIII) obtained their water for drinking from such boreholes thus enhancing infection.

There were several boreholes whose surrounding was damp with channels that drained dirty water back into the boreholes. Some boreholes had their opening at ground level hence not adequately covered and maintained (Plate U; Appendix VIII). This probably allowed excess water spilled on the ground and surface run offs during rainy season to enter the boreholes. This phenomenon was likely to transport intestinal geohelminth eggs carried in shoes and feet into the surrounding of boreholes from where they contaminate water (Drangert *et al*., 2010).

In related studies, human nematode eggs have been isolated from wells which were source of water for cooking and drinking (Jonnalagadda and Bhat, 1995; Maipanich *et al.*, 1995). Furthermore, surface run offs from the egg ladden soils in the fields and gardens (Maipanich *et al.*, 1995) would transport intestinal geohelminth eggs through poorly maintained porous wood covered and iron sheet covered boreholes. In contrast, the subjects' drinking water from concrete covered boreholes had low prevalence of intestinal geohelminths infections (3.86 %). This was probably because they were raised above ground level and were well covered and maintained to minimize run-off contamination (Plate S; Appendix VIII).

The infection with ascariasis (26.5%), trichuriasis (14.3%) and hookworm disease (7.5%) was higher in school children relying on communal piped water compared to those utilizing household piped water (Table 4.3, 4.4 and 4.5; Appendix XI). This finding concurs with those in a study from rural Honduran communities where tap water, as a source of drinking water was associated with high prevalence of *A. lumbricoides* (Smith *et al.*, 2001). It was evident that a lot of water spilled around communal taps making the surrounding moist (Plates P) and ideal for survival of *Ascaris* and *Trichuris* eggs (Gunawardena *et al.*, 2005).

The conditions at communal water taps were also favorable for the development and survival of hookworm larvae. The regions around communal taps are probably contaminated by multiple transportation of feacal matter in the users' feet and surface-runoffs from elsewhere such as open fields and untidy toilets. In contrast house hold piped water (Plate W; Appendix VIII) did not offer similar ideal conditions for the parasites survival, hence low prevalence.

#### 5.1.4.2 Impact of Personal Hygiene and Behavioral Habits on Prevalence of Geohelminths Nematodes

##### 5.1.4.2.1 Defecation Sites

There was high prevalence of the intestinal geohelminth parasites amongst the subjects that utilized the field, garden and drenches as their defecation site at night compared to those who relied on toilets (Tables 4.3, 4.4 and 4.5; Appendix XI). These were open areas where defecation is less unlikely in broad daylight but where children including adults could defecate in privacy at night. This behavioral habit could be due to the long distance between the residential house and toilet, and probably for fear of walking in darkness. Furthermore, most children tend to shun soiled toilets and prefer defecation outside next to the toilets especially in darkness.

These findings were in aggreement with previous studies that found most subjects accustomed to casual defecation in the "bush" (Gunawarden *et al.,* 2004) and ditches (Hadidjaja *et al.,* 1998) had high prevalence of intestinal geohelminth nematodes infections. In another related study, the subjects who used open fields for defeacation had markedly higher intestinal geohelminth infections than those who used latrines (Khan *et al*., 2004; Alum *et al.,* 2010). Intestinal geohelminth eggs from the faeces of infected children from these defecation sites contaminate soil (Anantaphruti *et al*., 2004) and infective eggs could easily be carried by water surface run-offs and wind to the ambient of boreholes, water points and playgrounds (Maipanich *et al*., 1995). However, this can also affect the children who use household toilets at night but play with the others in feacally contaminated playgounds at home and school.

Most of the sites used for feacal deposition are gardens located adjacent to toilets (Plate J; Appendix VI), open spaces near boreholes (Plate R; Appendix VIII) and communal pit latrines making the users of these facilities vulnerable to infection (Maipanich *et al.,* 1995; Anantaphruti *et al.,* 2004; Cheserek and Opata, 2011). In addition, the drenches and open fields in the "estate" lines were full of polythene papers, plastic materials and old newspapers used as peri-anal sanitary material intermingled with dried and fresh faecal matter (Plate Z; Appendix IX). This observation was in line with the findings of Hadidjaja *et al.* (1998) who found ditches full of garbage and human faeces in Northern

Jakarta, Indonesia. These act reservoirs for helminthes eggs and enhanced transmission, infection and re-infection amongst the residents.

#### 5.1.4.2.2 Toilet Cleanliness

The subjects whose toilets were never washed and cleaned regularly had high infection with ascariasis, trichuriasis and hookworm (Tables 4.3, 4.4 and 4.5; Appendix XI). The unwashed toilets could be source of infection and reinfection to the users (Alum *et al.*, 2010). It has also been reported that children tend to shun such soiled toilets (Drangert *et al.*, 2010) and hence prefer to defecate in the field or bush next to the toilets. This promotes contamination and transmission of the intestinal geohelminths infections.

It was observed that dirty water after washing clothes and cleaning houses was 'splashed' onto the floor of toilets. This 'splashing' style of toilet cleaning was also observed in the school latrines which caused moist toilet walls (Plate Y; Appendix IX). The water poured onto the floor of toilets scattered some faecal matter into the pit and to the outside through the door and through the porous toilet walls.

The implication of this phenomenon was that faecal matter containing nematode eggs spread into the vicinity of toilets.In some cases, vegetable gardens in their proximity become contaminated which would accelerate infection if the infected vegetables were poorly washed for cooking (Erdogrul and Sener, 2005; Avcioglu *et al*., 2011). It was evident that faecal contamination of the environment around latrines was likely high to an extent that usage of toilets by children who value sanitation offered little protection against transmission of ascariasis, trichuriasis and hookworm disease.

#### 5.1.4.2.3 Hand Washing After Defecation

The highest prevalence of ascariasis (22.5%), trichuriasis (13.8%) and hookworm disease (8.1%) occurred in the subjects who 'never' washed their hands with soap, followed by those who 'sometimes' washed their hands. It is apparent that the proportion of subjects practicing "sometimes" (42.6%) was dependent on the availability of washing facility or proximity of water when the situation demands. There was no soap available in toilets in school for handwashing. The habit of 'sometimes' washing hands without soap after defeacation was a high risk factor for transmission of intestinal geohelminth nematodes.

School toilets were located about 50 meters from water the taps. Therefore the frequency of hand washing in school after defecation may depend on whether the individual's fingers touched faeces during peri-anal cleanliness or the nearness of a person who values hygiene such as the parent and teacher (Drangert, 2010). Hand washing by the subjects was dependent on the source of water and availability. The subjects relying on boreholes used the readily available water in basins or containers placed near boreholes or else drawing water from boreholes to wash their hands could be a bother particularly in children. Furthermore, the subjects that confessed practicing "sometimes" washing hands after defecation probably gave panicky response on realizing the essence of the exercise in hygiene.

The results also showed that the subjects who "sometimes" and 'never' washed hands before eating had high infection with ascariasis, trichuriasis and hookworm. By not washing hands with soap before eating and after playing with soil and failure to wash hands after defecation are conforming factors to the prevalence of these parasites (Ezeagwuna *et al.,* 2010). A survey of hand washing in urban schools in Kenya involving 1000 participants reported that a quarter never actually washed hands with soap after visiting a toilet (Njuguna, 2009). The trend was risky given that hands readily become contaminated after defecation even with the use of toilet paper (Han *et al.,* 1988).

**5.1.4.2.4 Water Boiling Habits**

A high prevalence of intestinal geohelminth infections was recorded in children from families who never boil water and who sometimes boil water for drinking. This was significant because most of them obtained water from wood covered and iron sheet covered bore holes and communal piped water with moist surrounding conducive for thriving of intestinal geohelminths eggs/larvae. Furthermore, children do not drink water at home only but also drink unboiled water in school, neighbourhood and other places when thirsty or even share drinking water with school mates.

Some people boil drinking water but not water for washing utensils which could be contaminated if the water source is exposed to helminthes eggs. Water boiling in households was limited by the high cost of charcoal, firewood and kerosene, which are the common sources of cooking fuel in homes. This explains why most of the families never boil water or sometimes boil water for drinking.

An investigation on water used for drinking and cooking from different places in Hyderabad city in India showed that it was contaminated with eggs of *Ascaris* and *Trichuris* (Jonnalagada and Bhat, 1995). Intestinal geoelminth nematode eggs were also observed in drinking water drawn from wells (Maipanich *et al.*, 1995). Likewise, there is likelihood that borehole water in the study area was contaminated with helminthes eggs. This explains why boiling of drinking water had a significant bearing on intestinal geohelminth nematodes infection in children.

**5.1.4.2.5 Fruits and Vegetable Washing**

The prevalence of ascariasis was higher in the subjects that 'never' washed fruits and vegetables before eating/cooking followed by those who 'sometimes' washed (Tables 4.3, 4.4 and 4.5; Appendix XI). This was not unexpected because *Ascaris* eggs have an especially "sticky" nature that makes them adhere to fruits and vegetables (Kagei, 1983; Crompton *et al.,* 1989; Coelho *et al.,* 2001; Avcioglu *et al.,* 2011).

A study on contamination of various fruits and vegetables in Turkey showed that most of the fruits and vegetables sampled had *Ascaris* eggs (Erdogrul and Sener, 2005). In a related study in Nigeria, 97% of the food vendors were infected by one or more species of intestinal nematodes. In the present study, some of the predisposing factors in the fruit-borne outbreaks include the popular trend of eating fresh fruits bought from school vendors and street vendors without washing. Some of the vegetable gardens in study area with onions, kales and *Amaranthus* spp were located in close proximity to the toilets which enhanced the possibilities of contamination with feacal matter from the toilets through spillage of dirty water during cleanlining process. The prevalence of hookworm infection in the subjects that 'never' wash fruits and vegetables, and those that 'sometimes' wash them was low. This was probably because the main mode of hookworm transmission is through larval penetration of the host's skin (Gunawardena *et al.,* 2005).

**5.1.4.2.6 Finger Nails Cutting**

The school children who 'sometimes' and those who 'never' cut their finger nails exhibited a high prevalence of ascariasis and trichuriasis (Table 4.3 and 4.4; Appendix XI). The long unkempt nails that harbored *Ascaris* and *Trichuris* eggs would eventually transmit them to the subjects when eating food or sucking fingers. These findings were in agreement with other reports that dirty nails in school children were associated with high parasite infestation (Khan, 1979). Children with long fingernails carry helminthes eggs in their fingers when they touch contaminated objects and play with contaminated soils. In this circumstance, the helminthes eggs are swallowed when they suck their fingers, peel fruits and eat cooked solid foods such as 'ugali' and boiled potatoes with unwashed hands or washed hands with solid dirt stuck in the long finger nails.

In another study, increased risk of infection with intestinal geohelminth nematodes was reported in school-going children with dirty untrimmed finger nails (Dongre *et al.,* 2010). Herrstorm *et al.* (1997) reported that finger sucking in young Swedish children highly correlated with intestinal geohelminth infections. It was significant to note that in this study there was no infection with hookworm in the subjects that never cut their finger nails. This was because the entry route of hookworm is through larval penetration of the skin (Gunawardena *et al.,* 2005).

**5.1.4.2.7 Protective Footwear**

The use of footwear had a bearing on hookworm infection in the present study. The subjects who never wore shoes showed the highest prevalence of hookworm disease (28%) compared to the subjects that always wore shoes (2.4%). This confirmed finding from other studies which showed that wearing of shoes reduces the chance of contracting hookworm (Khan, 1979). Shoes prevent infective hookworm larvae from penetrating the human skin.

**5.1.4.2.8 Frequency of Deworming**

The schoolchildren who had ‘never’ been dewormed exhibited the highest prevalence of ascariasis, trichuriasis and hookworm followed by those who were ‘sometimes’ dewormed (Tables 4.3, 4.4 and 4.5; Appendix XI). There were no positive results for the three species of parasites in the schoolchildren who were always dewormed. This was in agreement with reports that deworming of children was a significant intervention method for controlling intestinal geohelimnth nematode infections in households (Sorensen *et al.*, 2011). This confirmed the view that chemotherapeutic control of intestinal geohelminthes infections in school children is more effective in reducing the number of disease cases than treatment of the total population (Gunawardena *et al;* 2004; Ekpenyong *et al*; 2008). In Kenya, a school-based anti-helmintic treatment program resulted in respective reductions in total egg excretion by 46% *Ascaris*, 29% *Trichuris* and 15% hookworm (Olsen, 1998).

### 5.1.4.3 Impact of Socio-Economic Factors on Prevalence of Human Intestinal Geohelimnth Infections

#### 5.1.4.3.1 House Type

The inhabitants of mud wall, earth floor and wood, cement floor houses are of low socio-economic status. The results showed that 79.9% of parents and /or guardians whose children participated in the study were low income earners. These findings were in line with previous research on environmental and housing problems in urban slums in Eldoret Municipality which found that low income earners reside in Langas and other slum estates due to poverty (Cheserek and Opata, 2011). The results also showed that a majority of low-income groups reside in slum areas due to poverty and partly as a result of low educational achievement that cannot enable them to obtain high-income jobs (Cheserek and Opata, 2011). Research has also shown that children from poorer dwellings with lower sanitation and hygiene were at higher risk of infection than better off groups (Caneiro *et al.,* 2002). Prevalnce was low for children who resided in concrete walled houses (Tables 4.3, 4.4 and 4.5; Appendix XI). This was probably because they were medium income earners who could afford deworming drugs, clean water for drinking and observed reasonable sanitary measures.

#### 5.1.4.3.2 Education Level of Parents/Guardian

The highest prevalence of the parasites was recorded in children whose parents and /or guardians were without formal education, followed by those whose parents or guardians had formal education (Tables 4.3, 4.4 and 4.5; Appendix XI). The least prevalence was in subjects whose parents or guardians had attained tertiary education (Tables 4.3, 4.4 and 4.5; Appendix XI). The well educated parents and/or guardians are more conscious about personal hygiene and health through the public media (radio, TV, newspapers and magazine). They teach children to adhere to high standards of personal hygiene and sanitary behavioral habits that reduce chances of transmission and infection by intestinal geohelminth nematodes. In addition, parents and/or guardians probably know the importance of deworming children.

The findings are in line with similar studies which showed that prevalence of ascariasis, trichuriasis and hookworm generally decline as the level of education increases (De silva *et al.,* 1996). It was also reported in a related study that the level of mothers' education affect intestinal geohelminth infection status of children. The prevalence was high in households with illiterate mothers (Sorensen *et al.,* 2011). Likewise, in this study the prevalence of intestinal geohelminths was high in children whose parents and/or guardians were without formal education. This could be attributed to their minimal knowledge on the importance of deworming and teaching children to shun behaviuor that would expose them to intestinal geohelminths infections.

**5.1.4.3.3 Parenthood, Household Assets and Household Income**

School children living with both parents had low prevalences of the intestinal geohelimnth nematodes investigated (Tables 4.3, 4.4 and 4.5; Appendix XI). The subjects of single parents/and or guardians had high prevalence of ascariasis and trichuriasis (Tables 4.3, 4.4 and 4.5; Appendix XI). This was probably due to the financial burden of a low income single parent or guardian who was unlikely to afford house rent for a decent living house and to buy anti-helminthic drugs for children. Furthermore, most single parents may not have adequate time to monitor the unsanitary behavioural habits of children and also to deworm them especially when they are asyptomatic.

The parents' socio-economic status using household-based asset approach was adapted from previous studies in Tajikistan (Matthys *et al.*, 2011). The children who were stratified in the top class had low intestinal geohelminth namatodes infections. This was probably because they could be of parents and/or guardians of high socio-economic status residing in specific locations within Langas with good sanitary conditions, modern houses (plate AC; Appendix X) and clean drinking water. This results corrobrates other findings that slums may contain siginificant percentages of housesholds expenditures and living status that would put them above the poverty line in the neighbourhood (Matthys *et al.*, 2011). The children falling under bottom class had the highest geohlminthiases compared to middle class children.This finding concurs with other studies that have shown an increase in prevalence of helminthes as the socioeconomic class declined (De Silva *et al*., 1996). These are children residing in the wider slum characterized by poor housing, unclean drinking water and untidy toilets which expose them to intestinal geohelminth nematodes infections.

The infectivity with ascariasis, trichuriasis and hookworm disease was highest amongst the subjects of the unemployed at 53.8%, 38.5% and 23.1% respectively. This was followed by the self employed at the prevalence rates of 39.7% ascariasis, 22.6% trichuriasis and 13.7% hookworm disease. These findings were in accordance with a previous study conducted in Eldoret Municipality (Cheserek and Opata, 2011) who reported that a large percentage of the residents of Langas were unemployed and self-employed.

Those who confessed being unemployed were housewives without any income, the self-employed sold vegetables and foodstuffs or ran food canteens and those with formal employment were watchmen, security personnel and nursery school teachers. These cadres of people earn little and live on unstable income. In view of this, the parents and/or guardians are categorized as of low economic status and live in the Langas slums with affordable degrading rental houses and filthy environment that expose their school age children to intestinal geohelminth infection. Previous research showed that schoolchildren whose parents are low income earners had high prevalence and infection rates of intestinal geohelminth nematode infections (De silva *et al*., 1996; Ananthaphruti *et al.*, 2004; Uga *et al.*, 2005).

**5.2 Conclusion**

1. Individuals aged 11-13 years old had significantly the highest prevalence of the nematode infections (75.4%), $p<0.005$.
2. 159(55.8%) children had intestinal geohelminth nematode infections with males being more infected than the females (56.8% vs. 43.2%).
3. The specific prevalence of infections were *Ascaris Lumbicoides* 80 (28.1%), *Trichuris trichiura* 50 (17.5%) and hookworms 29 (10.2%) while 71 (44.7%) had multiple infections.

4. The overall mean intensities of the infections were *Ascaris lumbicoides* 256.32 ± 94.90 eggs/g, *T. trichiura* 102 ± 14.10 eggs/g and hookworm 120.69 ±77.4 eggs/g of stool
5. Sanitary resources and conditions principally toilet availability and toilet type, water source, backyard home (compound) environment and school ground cover; personal hygiene and behavioural habits mainly toilet cleanliness, fingernails trimming and shoes wearing; and socio-economic factors mainly house type, employment status, education level and household income were implicated in this study as factors enhancing exposure to intestinal geohelminth infections. Each of the above factors has been exaggerated by socio-economic status of households.
6. Personal hygiene (fruit washing) and poor environmental hygiene (defecation site at night) were probably the major risk factors that were identified to be the cause in the transmission of intestinal geohelminthes nematodes among primary school children in langas.

## 5.3 Recommendations

1. Targeted deworming of schoolchildren should be considered since these intestinal geohelminth nematodes are potentially treatable by a single dose of albendazole or mebendazole.

2. Countermeasures such as health education on sanitary resources and their conditions with emphasis on clean water for domestic use, raised concrete covered boreholes, toilet cleanliness, non-disposal of feacal matter in vegetable

gardens and grass covered backyard home environment can drastically reduce prevalence of intestinal geohelminth nematodes.

3. Health education would be instrumental in educating illiterate and semi illiterate parents/guardians on the need of sanitary practices and deworming their children.
4. The government, through the Ministry of Housing should build low cost houses to upgrade the slum houses.
5. Further research on these factors, based on prospective study design should be conducted in all schools within Eldoret municipality.

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# APPENDICES

## Appendix I: Questionnaire

This questionnaire was specially designed as a data collection instrument. The questionnaire was based on the variables used in the construction of the three indices: Sanitary resources and conditions, Personal hygiene and behavioral habits, and Socio-economic factors (Fernando Ferreira Carneiro et al; 2002).

**Instructions**

- This questionnaire into divided into three parts:

  Part I-details from schoolchildren

  Part II-details gathered from the field

  Part III-details gathered from parents and/or guardians

- The answers were incorporated with the microscopic examination of stool samples.
- The class teachers sat with together with their respective pupils and asked the following questions.
- School children were asked to tick or fill in the spaces provided one or more of the correct answers.

**Part I: Details from schoolchildren**

**1.0 School record**

1.1 Code number:

1.2 Class:

1.3 Age(years)

1.4 Gender: Male( ) Female ( )

1.5

**2.0 Sanitary resources and conditions**

2.1 Do you have a toilet at home?

(a) No

(b) Yes

2.2 Which is the toilet type at home?

(a) Household pit latrine

(b) Communal pit latrine

(c) Inside House toilet (Flush type)

2.3 Which is the source of your bathing and drinking water?

(a) Bore hole

(b) Communal Piped water

(c) House Piped water

2.4 If the source of water is borehole, which one describes its conditions?

(a) Open/Uncovered

(b) Wood covered

(c) Iron sheet covered

(d) Concrete covered

**2.**5 Which one describes the backyard home environment?

(a) Bare ground

(b) Grass covered

(c) Garden

(d) Concrete

**3.0 Personal hygiene and behavioral habits**

3.1 What facility is your defecation site at night?

(a) Open field

(b) Garden

(c) Drenches

3.2 How frequent do you clean your toilets?

(a) Never

(b) Sometimes

(c) Always

3.3 Do you wash your hands with soap after defecation and before meals?

(a) Never

(b) Sometimes

(c) Always

3.4 Do you boil water before drinking?

(a) Never

(b) Sometimes

(c) Always

3.5 Do you wash fruits and vegeatables before eating?

(a) Never

(b) Sometimes

(c) Always

3.6 Do you cut your fingernails?

(a) Never

(b) Sometimes

(c) Always

3.7 How often do you wear shoes?

(a) Never

(b) Sometimes

(c) Always

3.8 How frequently do you take ant-helmintic tablets?

(a) Never

(b) Sometimes

(c) Always

3.9 When did you last take ant-helmintic tablets?

(a) Less than one year

(b) 1-2 years

(c) 3-4 years

(d) Above 4 years

(e) Not at all

**4.0 Socio-economic aspects**

4.1 In which type of house do you live?

(a) Concrete

(b) Mud wall, earth floor

(c) Mud wall, Cement floor

(d) Wood, Cement floor

(e) Wood, earth floor

4.2 Whom are you currently living with?

(a) Single parent

(b) Both parents

c) Guardian

4.3 Which of the following household assets do you own at home?

(a) Car ( )

(b) Refrigerator ( )

(c) DVD recorder ( )

(d) Colour TV ( )

(e) Black and White TV ( )

(f)Radio ( )

**Part II: Details gathered from the Field (Personal observation)**

4.1 Gender

(a) Male

(b) Female

4.2 Availability of toilets

(a)Available

(b) Not available

4.3 Toilet type at home

(a) House hold pit latrine

(b)Communal pit latrine

(c)Inside house toilet

4.4 Source of bathing and drinking water

(a)Borehole

(b)Communal piped water

(c) House piped water

4.5 Availability and usage of soap at toilets in selected homes and at school

(a) Available

(b) Not available.

4.6 Nature of boreholes

(a) Open/uncovered boreholes

(b) Wood covered

(c) Iron sheet covered

(d) Concrete covered

4.7 Nature of backyard home environment and school environment

(a) Bare ground

(b)Grass covered

(c) Garden

(d) Concrete

4.8 Defecation site at night

(a) Open field

(b) Garden

(c) Drenches

(d) Toilet

4.9 Toilet cleanliness

(a) Never( 0 )

(b) Sometimes (5 points)

(c) Always (10 points)

4.10 Hand wash with soap after defecation

(a) Soap available(10 points)

(b) Soap unavailable (0)

4.11 Fruits washing before eating

(a) Wash

(b) Eat without washing

4.12 Finger nails trimming

(a) Trimmed

(b)Untrimmed

4.13 Shoes wearing

(a)Wearing shoes

(b) Without shoes

4.14 House type

(a) Concrete

(b) Mud wall, earth floor

(c) Mud wall, Cement floor

(d) Wood, Cement floor

(e) Wood, earth floor

**Part III: Details from parents and /or guardians**

5.1 Which is the highest level of education of the head of family?

(a) Primary education

b) Secondary education

(c) Tertiary education

(e) None

5.2 What is your total monthly income?

(a) Less than Ksh 5000.00

(b) Ksh 5001.00-10,000.00

(c) Ksh 10,001.00-15,000.00

(d) Ksh 15,001.00-20,000.00

(e) Ksh 20,001.00-25,000.00

(f) Above Ksh 25,000.00 but less than 119,999.0

(g) Above Ksh 120,000.00

**Appendix II: Consent Form for the Parents and/or guardians of Participants**

I am a postgraduate student from the faculty of science, Department of Biological Sciences at the University of Eldoret. I am here to study intestinal geohelminth nematode infections in school children at Langas Primary School. I request to pass over vital information about soil-transmitted helminths and also on the collection of stool samples from your children for microscopic examination of helminth eggs.

The results of microscopic examination of stool samples will be kept confidential. The laboratory findings will be used to initiate chemotherapy in the school and may also be used by the Ministry of Health Services and Sanitation or any volunteer to design and implement control strategies in the school and Langas area. At the end of the study, a report will be compiled and presented to the faculty of science and department of biological sciences of University of Eldoret. With permission from the faculty, findings may also be communicated to the Municipal Officer of Health and the Head teacher of Langas Primary School. Such a report will not bear any information on any participant's health status. You have the right to decline to cooperate in the study. If you have understood the explanation well enough, append your signature below.

I, the undersigned parent and/guardian of………………..in class………., have been informed about the study objectives. I have also been informed that all the information within the questionnaire is to be kept confidential and that I have the right to decline from or to cooperate in the study. Therefore, with full understanding of the study objectives I agree to give the informed consent voluntarily to the researcher to interview my child and collect his/her stool sample for identification of intestinal parasites.

Name of Parent/Guardian…………..Signature……………Date…………………….

**Appendix III: Prevalence and Intensities of Infection**

**3.1 Calculation of Prevalence Infection**

Calculation of the mean prevalence (%) of the helminthes was obtained by formula:

$$\text{Mean prevalence (\%)} = \frac{X}{N} \times 100$$

Where

X = Total number of children positive

N = Total number of children examined

**3.2 Calculation of Intensity of Infection**

i. Intensities were calculated using Stoll's technique (refer laboratory techniques)

ii. $$\text{Mean intensity} = \frac{\text{Total number of eggs per gram of each faecal matter}}{\text{Total number of children examined}}$$

## Appendix IV: Preparation of Reagents and Solutions

### 4.1 Iodine (Dobell's) for Faecal Preparations

***To make about 100ml:***

| | |
|---|---|
| Potassium iodide | 4g |
| Iodine | 2g |
| Distilled water | 100ml |

**Procedure**

1. 4g of potassium iodide will be weighed and dissolved completely in 50 ml of distilled water.
2. 2g of iodine is added to the potassium solution and mixed well to dissolve.
3. The remaining 50 ml of distilled water is added to the solution in step 2 above and mixed thoroughly before transferring to a brown bottle.
4. The reagent in the brown bottle will be labeled and marked **harmful**. It will be stored in the dark at room temperature.
5. It will be transferred to a small brown bottle with a cap into which a dropper can be inserted.
6. The reagent can remain stable for several months (Cheesbrough, 2005).

### 4.2 Bayer's Stock Solution

***To make about 107 ml:***

| | |
|---|---|
| Copper II chloride | 0.7g |
| Acetic acid, glacial | 7ml |
| Formalin, 20%v/v | 100ml |

**Procedure**

1. 20 ml of concentrated formaldehyde solution (37-40% v/v) will be mixed with 80 ml of distilled water to make 20% v/v of Formalin solution.
2. 100ml of Formalin solution will be well mixed with 7ml of Acetic acid, glacial.
3. The resulting solution in step 2 will be added to 0.7g of Copper II chloride in a leak-proof bottle and mixed until the chloride is completely dissolved.
4. The reagent will be transferred to a bottle, labeled and marked *Corrosive* and *Toxic*.
5. It will be stored at room temperature in a safe place.
6. The reagent is stable indefinitely (Cheesbrough, 2005).

### 4.3 Formol water, 10%v/v

**Procedure**

1. 50 ml of a strong formaldehyde solution is mixed with 450 ml of distilled water.
2. The mixture will thoroughly be shaken in a stoppered flask and labeled.
3. The reagent will be stored in a safe place (Cheesbrough, 2005.

**Appendix V: Helminths Ova**


**Plate A: Unfertilized egg of *A. lumbricoides* with uneven albuminous coat 200 x magnifications. Plate B: Unfertilized egg of *A. lumbricoides* in an unstained wet mount, x200 × magnification.*Adopted: DPDx Parasite image library, The Leiden University Medical Center, The Netherlands.***

**Plate C Decorticated outer layer** **Plate D**

**Plate C: Unfertilized egg of *A. lumbricoides* in an unstained wet mount of stool.magnification, x 200. Plate D: Unfertilized egg of *A. lumbricoides* with decorticated outer layer in a wet mount of stool.magnification, x200. *Adopted: DPDx Parasite image library, The Leiden University Medical Center, The Netherland***

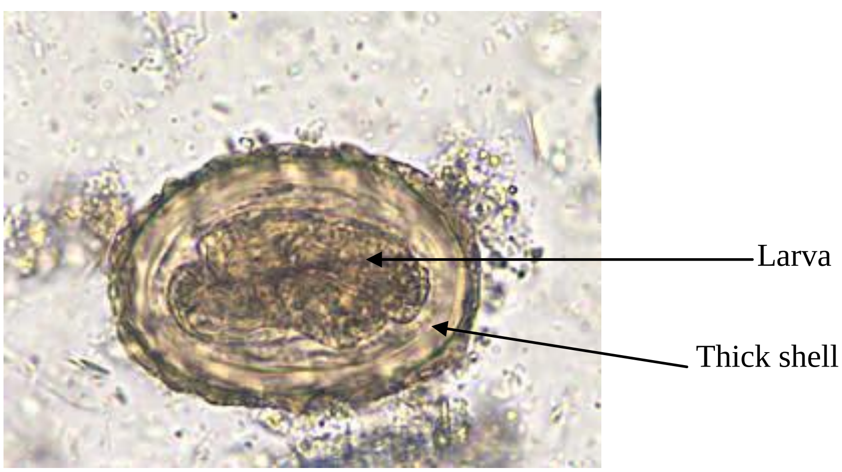


**Plate E: A fertilized egg of *A. lumbricoides* with a visible larva**. ***Adopted: DPDx Parasite image library, The Leiden University Medical Center The Netherland.***


**Plate F: Eggs of *T. trichiura* under high power microscope (stained in iodine) magnification x200.** ***Adopted: DPDx, parasite image library, CDC***

**Plate G: Hookworm eggs in a stool sample of a pupil, magnification x450. *Adopted:from youn Suk Ryang,Web Atlas of Medical Parasitology(2003)*.**

# APPENDIX VI: TOILET TYPES

**Plate H: Inside house toilet (Flush type) from a house in Kisumu Ndogo. (Source: Author, 2011)**


Plate I: Household pit latrine from a home at Panama **(Source: Author, 2011)**


**Plate J: Communal pit latrines from estate"Lines"at Kasarani (Source: Author, 2011)**

# APPENDIX VII: BACKYARD HOME AND SCHOOL ENVIRONMENT


**Plate K: Bare (Home Backyard at Kambi Nguruwe (Source: Author, 2011)**


**Plate L: Bare School Backyard at Langas Primary (Source: Author, 2011)**


**Plate M: Grass Covered Home backyard at Kona Mbaya (Source: Author, 2011)**

**Plate N: Concrete Home Backyard at Kisumu Ndogo (Source: Author, 2011)**


**Plate O: Broken Sewerage Line near Langas Primary's Gate (Source: Author, 2011)**

## APPENDIX VIII: TYPES OF WATER SOURCES


**Plate P: Communal Piped Water at Kahuruko (Source: Author, 2011)**


**Plate Q: Communal Piped Water at Kisumu Ndogo (Source: Author, 2011)**


**Plate R: Wood Covered Borehole near Police Post Langas (Source: Author, 2011)**


**Plate S: Concrete Raised Wood Covered Borehole at Kambi Nguruwe (Source: Author, 2011)**


**Plate T: Concrete Wood Covered Borehole near Langas Primary School (Source: Author, 2011)**


**Plate U: Concrete Covered Borehole at Ground Level at Kisumu Ndogo (Source: Author, 2011)**


**Plate V: Municipal Water Kiosk at Kisumu Ndogo (Source: Author, 2011)**

**Plate W: Household Piped Water in a House near Gorofani (Source: Author, 2011)**

## APPENDIX IX: TOILET CLEANLINESS


**Plate X: Concrete Pit Latrine with Untidy floor at Kona Mbaya (Source: Author, 2011)**

**Plate Y: Concrete pit latrines in Langas Primary**

**(Source: Author, 2010)**


**Plate Z: Pit latrine at Kwa Ngasha**

**(Source: Author, 2010)**


**Plate AA: Concrete Pit Latrine with Untidy Floor**

**(Source: Author, 2010)**

**APPENDIX X: TYPES OF HOUSES**

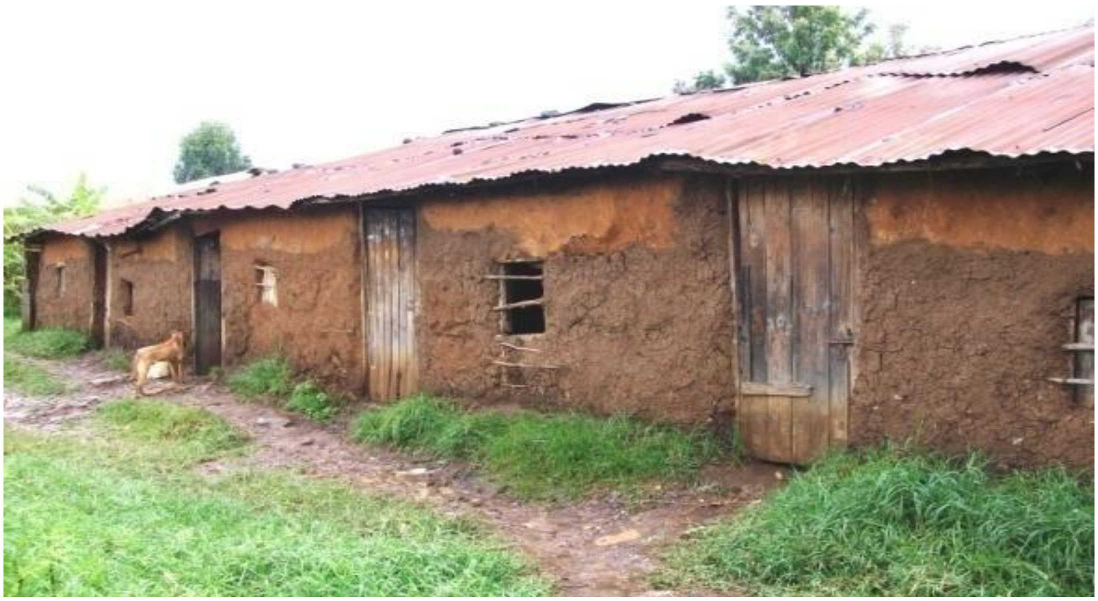

**Plate AB: Mud wall earth floor house Langas Health center**

**(Source: Author, 2010)**

**Plate AC: Concrete house near Gorofani**

**(Source: Author, 2010**

**Plate AD:  Woodwall, cement floor house at Kasarani**

**(Source: Author, 2010)**

**Plate AE: Mudwall, cement floor house at Panama**

**(Source: Author, 2010)**


**Plate AF:  Woodwall, earth floor house at Kasarani**

**(Source: Author, 2010)**

**Appendix XI: Prevalence and Intensity of Intestinal Geohelminth Nematodes Infections/Diseases**

**Table 4.3: Factors associated with *Ascaris* infection**

| Factor | ***Ascaris* infection** | | chi-value | p-value |
|---|---|---|---|---|
| | **Positive (%)** | **Negative (%)** | | |
| **Gender of the child** | | | | |
| Male | 43(29.1) | 105(70.9) | 0.148 | 0.701 |
| Female | 37(27) | 100(73) | | |
| **Water source** | | | | |
| Borehole | 28(50) | 28(50) | 19.572 | **<0.001** |
| Communal piped | 39(26.5) | 108(73.5) | | |
| H/hold piped | 13(15.9) | 69(84.1) | | |
| **Water boiling** | | | | |
| Never | 36(41.4) | 51(58.6) | 19.030 | **<0.001** |
| Sometimes | 28(32.6) | 58(67.4) | | |
| Always | 16(14.3) | 96(85.7) | | |
| **Toilet type** | | | | |
| H/hold pit latrine | 19(26.8) | 52(73.2) | 23.589 | **<0.001** |
| Communal pit latrine | 58(37.9) | 95(62.1) | | |
| Inside house toilet | 3(4.9) | 58(95.1) | | |

| | | | | |
|---|---|---|---|---|
| **Income** | | | | |
| Medium | 66(25.4) | 194(74.6) | | |
| Low | 14(58.3) | 10(41.7) | 12.205 | **0.002** |
| High | 0(0) | 1(100) | | Fisher's exact |
| **Hand washing after defecation and before meals** | | | | |
| Never | 23(42.6) | 31(57.4) | | |
| Sometimes | 21(29.6) | 50(70.4) | 8.179 | **0.017** |
| Always | 36(22.5) | 124(77.5) | | |
| **Fruit and vegetable washing** | | | | |
| Never | 23(53.5) | 20(46.5) | | |
| Sometimes | 53(38.1) | 86(61.9) | 40.958 | **<0.001** |
| Always | 4(3.9) | 99(96.1) | | Fisher's exact |
| **House type** | | | | |
| Concrete | 16(13.3) | 104(86.7) | 40.958 | **<0.001** |
| Mud wall, earth floor | 18(50) | 18(50) | | |
| Wood, cement floor | 18(52.9) | 16(47.1) | | |
| Mud wall, cement floor | 22(25.3) | 65(74.7) | | |
| Wood, earth floor | 6(75) | 2(25) | | |
| **Parent/guardian education** | | | | |
| Primary | 40(38.1) | 65(61.9) | 35.763 | |
| Secondary | 22(18) | 100(82) | | **<0.001** |
| Tertiary | 5(12.5) | 35(87.5) | | |
| None | 13(76.5) | 4(23.5) | | |

| | | | | |
|---|---|---|---|---|
| **Defecation site at night** | | | | |
| Field | 14(53.8) | 12(46.2) | | |
| Garden | 14(56) | 11(44) | 36.585 | **<0.001** |
| Drench | 6(85.7) | 1(14.3) | | Fisher's exact |
| Toilet | 46(20.3) | 181(79.7) | | |
| **Nature of borehole** | | | | |
| Wood covered | 17(54.8) | 14(45.2) | | |
| Iron sheet covered | 10(50) | 10(50) | 19.285 | **<0.001** |
| Concrete | 2(18.2) | 9(81.8) | | Fisher's exact |
| None | 51(22.9) | 172(77.1) | | |
| **Backyard home environment** | | | | |
| Bare ground | 53(48.2) | 57(51.8) | | |
| Grass covered | 26(19.8) | 105(80.2) | 40.926 | **<0.001** |
| Concrete | 1(2.3) | 43(97.7) | | |
| **Finger nail cleanliness** | | | | |
| Sometimes | 60(45.8) | 71(54.2) | | |
| Always | 16(10.7) | 134(89.3) | 53.150 | **<0.001** |
| Never | 4(100) | 0(0) | | Fisher's exact |
| **Frequency of deworming** | | | | |
| Sometimes | 52(34.2) | 100(65.8) | 110.782 | |
| Always | 0(0) | 104(100) | | **<0.001** |
| Never | 28(96.6) | 1(3.4) | | |

**Table 4.4: Factors Associated with *Trichuris* Infection**

| Factor | *Trichuris* infection | | chi-value | p-value |
|---|---|---|---|---|
| | **Positive** | **Negative** | | |
| **Gender of the child** | | | | |
| Male | 30(20.3) | 118(79.7) | 1.582 | 0.208 |
| Female | 20(14.6) | 117(85.4) | | |
| **Water source** | | | | |
| Borehole | 23(41.1) | 33(58.9) | | **<0.001** |
| Communal piped | 21(14.3) | 126(85.7) | 28.436 | |
| H/hold piped | 6(7.3) | 76(92.7) | | |
| **Water boiling** | | | | |
| Never | 18(20.7) | 69(79.3) | | |
| Sometimes | 21(24.4) | 65(75.6) | 8.022 | **0.018** |
| Always | 11(9.8) | 101(90.2) | | |
| **Toilet type** | | | | |
| H/hold pit latrine | 12(16.9) | 59(83.1) | | **0.002** |
| Communal pit latrine | 36(23.5) | 117(76.5) | 12.390 | |
| Inside house toilet | 2(3.3) | 59(96.7) | | |
| **Income** | | | | |
| Medium | 37(14.2) | 223(85.8) | 24.437 | **<0.001** |
| Low | 13(54.2) | 11(45.8) | | Fisher's exact |
| High | 0(0) | 1(100) | | |
| **Hand washing after defecation and before meals** | | | | |
| Never | 12(22.2) | 42(77.8) | | |
| Sometimes | 16(22.5) | 55(77.5) | 3.632 | 0.163 |

| | | | | |
|---|---|---|---|---|
| Always | 22(13.8) | 138(86.2) | | |
| **Fruit and vegetable washing** | | | | |
| Never | 18(41.9) | 25(58.1) | | |
| Sometimes | 30(21.6) | 109(78.4) | 36.476 | **<0.001** |
| Always | 2(1.9) | 101(98.1) | | |
| **House type** | | | | |
| Concrete | 7(5.8) | 113(94.2) | | |
| Mud wall, earth floor | 14(38.9) | 22(61.1) | 30.456 | **<0.001** |
| Wood, cement floor | 9(26.5) | 25(73.5) | | |
| Mud wall, cement floor | 16(18.4) | 71(81.6) | | |
| Wood, earth floor | 4(50) | 4(50) | | |
| **Parent/guardian education** | | | | |
| Primary | 25(23.8) | 80(76.2) | 31.148 | |
| Secondary | 14(11.5) | 108(88.5) | | **<0.001** |
| Tertiary | 1(2.5) | 39(97.3) | | Fisher's exact |
| None | 10(58.8) | 7(41.2) | | |
| **Defecation site at night** | | | | |
| Field | 12(46.2) | 19(61.3) | | |
| Garden | 12(48) | 12(60) | 20.410 | **<0.001** |
| Drench | 3(42.9) | 9(81.8) | | |
| Toilet | 23(10.1) | 195(87.4) | | |
| **Nature of borehole** | | | | |
| Wood covered | 12(38.7) | 19(61.3) | | |
| Iron sheet covered | 8(40) | 12(60) | 20.410 | **<0.001** |
| Concrete | 2(18.2) | 9(81.8) | | |
| None | 28(12.6) | 195(87.4) | | |

| | | | | |
|---|---|---|---|---|
| **Backyard home environment** | | | | |
| Bare ground | 31(28.2) | 79(71.8) | | |
| Grass covered | 18(13.7) | 113(86.3) | 17.008 | <**0.001** |
| Concrete | 1(2.3) | 43(97.7) | | |
| **Finger nail cleanliness** | | | | |
| Sometimes | 38(29) | 93(71) | 27.082 | <**0.001** |
| Always | 10(6.7) | 140(93.3) | | Fisher's exact |
| Never | 2(50) | 2(50) | | |
| **Frequency of deworming** | | | | |
| Sometimes | 32(21.1) | 120(78.9) | | |
| Always | 0(0) | 104(100) | 63.164 | <**0.001** |
| Never | 18(62.1) | 11(37.9) | | |

**Table 4.5: Factors associated with hookworm infection**

| Factor | Hookworm infection | | chi-value | p-value |
|---|---|---|---|---|
| | **Positive** | **Negative** | | |
| **Gender of the child** | | | | |
| Male | 11(7.4) | 137(92.6) | 2.534 | 0.111 |
| Female | 18(13.1) | 119(86.9) | | |
| **Water source** | | | | |
| Borehole | 10(17.9) | 46(82.1) | | |
| Communal piped | 11(7.5) | 136(92.5) | 4.797 | 0.091 |
| H/hold piped | 8(9.8) | 74(90.2) | | |
| **Water boiling** | | | | |
| Never | 11(72.6) | 76(87.4) | | |
| Sometimes | 11(12.8) | 75(87.2) | 3.112 | 0.211 |
| Always | 7(6.2) | 105(93.8) | | |
| **Toilet type** | | | | |
| H/hold pit latrine | 9(12.7) | 62(87.3) | | 0.130 |
| Communal pit latrine | 18(11.8) | 135(88.2) | 4.083 | |
| Inside house toilet | 2(3.3) | 59(96.7) | | |
| **Income** | | | | |
| Medium | 22(8.5) | 238(91.5) | | **0.005** |
| Low | 7(29.2) | 17(70.8) | 10.419 | Fisher's exact |
| High | 0(0) | 1(100) | | |
| **Hand washing after defecation and before meals** | | | | |
| Never | 6(11.1) | 48(88.9) | | |
| Sometimes | 10(14.1) | 61(85.9) | | |
| Always | 13(8.1) | 147(91.9) | 1.975 | 0.373 |

| | | | | |
|---|---|---|---|---|
| **Fruit and vegetable washing** | | | | |
| Never | 9(20.9) | 34(79.1) | | |
| Sometimes | 16(11.5) | 123(88.5) | 10.174 | **0.006** |
| Always | 4(3.9) | 99(96.1) | | |
| **House type** | | | | |
| Concrete | 3(2.5) | 117(97.5) | | **0.006** |
| Mud wall, earth floor | 6(16.7) | 30(83.3) | 14.640 | Fisher's exact |
| Wood, cement floor | 6(17.6) | 28(82.4) | | |
| Mud wall, cement floor | 12(13.8) | 75(86.2) | | |
| Wood, earth floor | 2(25) | 6(75) | | |
| **Parent/guardian education** | | | | |
| Primary | 11(10.5) | 94(89.5) | | |
| Secondary | 10(8.2) | 112(91.8) | 13.398 | **0.004** |
| Tertiary | 2(5) | 38(95) | | |
| None | 6(35.3) | 11(64.7) | | |
| **Defecation site at night** | | | | |
| Field | 5(19.2) | 21(80.8) | | |
| Garden | 6(24) | 19(76) | 9.606 | **0.022** |
| Drench | 0(0) | 7(100) | | |
| Toilet | 18(7.9) | 209(92.1) | | |
| **Nature of borehole** | | | | |
| Wood covered | 7(22.6) | 24(77.4) | | |
| Iron sheet covered | 4(20) | 16(80) | 8.935 | **0.030** |
| Concrete | 1(9.1) | 10(90.9) | | Fisher's exact |
| None | 17(7.6) | 206(92.4) | | |

| | | | | |
|---|---|---|---|---|
| **Backyard home environment** | | | | |
| Bare ground | 19(17.3) | 91(82.7) | | |
| Grass covered | 10(7.6) | 121(92.4) | 11.973 | **0.003** |
| Concrete | 0(0) | 44(100) | | Fisher's exact |
| **Finger nail cleanliness** | | | | |
| Sometimes | 22(16.8) | 109(83.2) | | |
| Always | 7(4.7) | 143(95.3) | 11.712 | **0.003** |
| Never | 0(0) | 4(100) | | Fisher's exact |
| **Frequency of deworming** | | | | |
| Sometimes | 19(12.5) | 133(87.5) | | |
| Always | 4(3.8) | 100(96.2) | 8.964 | **0.011** |
| Never | 6(20.7) | 23(79.3) | | |