EFFECTIVENESS OF ALBENDAZOLE ON SOIL TRANSMITTED NEMATODES AMONG SCHOOL GOING CHILDREN IN KAKAMEGA COUNTY, KENYA

BY

TERESIA WAMBUI. NGONJO, (MSc)
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DECLARATION

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

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

Teresia Wambui Ngonjo - P97/21879/2010

Department of Community Health and Epidemiology

SUPERVISORS

We confirm that the work reported in this thesis was carried out by the candidate under our supervision as University supervisors

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

Prof. Ephantus W. Kabiru

Department of Community Health and Epidemiology

Kenyatta University

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

Dr Eric Lelo

Centre of Biotechnology Research Development

Kenya Medical Research Institute – Nairobi

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

Dr Charles Mwandawiro

Eastern and Southern African Centre of International Parasite Control

Kenya Medical Research Institute - Nairobi

DEDICATION

I dedicate this work to my family who supported and encouraged me throughout the study, my spouse, Stephen Ngonjo, my children, Valerius Gacheru, Prisca Wangui and Celian Waithera.

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OPERATIONAL DEFINITION OF TERMS

Anemia Clinical condition reflecting an inadequate number of red blood cells or an insufficient amount of hemoglobin (Hb) in the blood.

Anthelminthic Resistance

Is an indication of reduction in the effect of a drug against a population of parasites which were commonly susceptible to a particular drug

Cure rate Percentages ratio of baseline prevalence becoming parasitological negative after treatment.

Egg reduction rate (ERR)

The change in mean eggs per gram (epg) counts after an intervention (e.g. deworming) in a population. The post treatment mean epg count is compared with a baseline, or pre-treatment, mean epg count. It is expressed as a percentage (1 - mean post-deworming epg/mean pre deworming epg).

Endemic area Area in which a disease is intensively transmitted.

Good latrine structural condition

Latrine with roof, walls with no holes, door stables with slab floors

Hygiene behavior

Washing of hands with soap before eating and toilet visits

Improved Water Source

Access to piped water into yard, public tap, boreholes, protected wells or springs, rain water collection and bottled water

Infected Children whose stool samples were positive for STN eggs by microscopy

Intensity of infection

Number of worms infecting an individual. It is measured directly, by counting expelled worms after anthelminthic treatment, or indirectly, by counting helminth eggs excreted in faeces (expressed as eggs per gram, epg).

Intestinal obstruction

Blockage of the intestinal lumen.

Mass drug administration.

The entire population of an area is given anthelminthic drugs at regular intervals, irrespective of the individual health status.

Malabsorption

Reduced capacity to absorb nutrients through the gastrointestinal tract.

Morbidity: Refers to having a disease or a symptom of disease, or to the amount of disease within a population, as a result of STNs infections

Pathology: Means of study of deviation from a healthy, concerned with disease, especially its structure and its functional effects on the body

Preschool-age children

Children between 1 and 4 years of age.

Prevalence: The proportion of a particular population found to be infected by a disease i.e Soil Transmitted Nematodes that are present in a particular population at a given time

Preventive chemotherapy

The use of anthelminthic drugs, either alone or in combination, as a public health tool against helminth infections.

Rectal prolapse

Medical condition in which the wall of the rectum protrudes through the anus and become visible outside the body.

Refugia: The proportion of the parasite population that is not exposed to drugs and thus escapes selection for resistance

Soil-transmitted Nematodes

Different species of nematodes that include, *Ascaris lumbricoides*, roundworms; *Trichuris trichiura*, whipworm; *Necator americanus* and *Ancylostoma duodenale*, hookworm which are transmitted through contaminated soil

Hygiene Practices that help to sustain health and prevent the spread of diseases, hand washing with soap or other agents, food hygiene, overall personal hygiene including laundry, and environmental cleaning.

Integration

Joint planning, implementation, and evaluation of activities across sectors and programmes.

Preventive Chemotherapy

This is regular, large-scale administration of drugs – either alone or in combination, to population groups, with the aim of reducing transmission and associated morbidity.

Rectal prolapse

It is a complication associated with heavy *Trichiuris trichiura* infection that lead to protrusion of rectum wall through the anus to the outside of the body.

Sanitation: The provision of facilities and services for the safe disposal of human excreta. It refers to the safe management of excreta from collection, emptying, transport, treatment and disposal or reuse.

School-age children

Usually defined as children between 5 and 14 years of age who may or may not be enrolled in school.

Sustainable WASH

Refers to the continued functioning and utilisation of water and sanitation services as well as lasting changes in human behaviour around hygiene and safe sanitation. Sustainability is about services that continue in use indefinitely and that consequently transform people's lives for good.

Water Supply

The provision of water by public utilities, commercial organisations, community endeavours or by individuals, usually via a system of pumps and pipes.

LIST OF ABBREVIATIONS AND ACRONYMS.

ALB	Albendazole
AR	Anthelminthic Resistance
BZ	Benzimidazole
CBRD	Centre of Biotechnology Research Development
CDC	Center for disease control
CDTI	Community-directed treatment with ivermectin
CR	Cure Rates
DALYs	Disability Adjusted Life Years
DNA	Deoxyribonucleic Acid
EHT	Egg Hatch Test
Epg	Eggs per Gram
ERR	Egg reduction Rates
ESACIPAC	Eastern and Southern African Centre of International Parasite Control
FEC	Feacal Egg Count
FECR	Fecal Egg Count Reduction
FRESH	Focusing Resources on Effective School Health
IVM	Ivermectin
LMICs	low and middle income countries)
MDA	Mass Drug Administration
MBD	Mebendazole
MoEST	Ministry of Education, Science and Technology
NSBDP	National school-based deworming programme.
NTDS	Neglected Tropical Diseases

OR	Odd Ratio
SAC	School Age Children
PSAC	Preschool age children
RFLP	Restriction Fragment Length Polymorphism
SNP	Single Nucleotide Polymorphism
STNs	Soil-transmitted Nematodes
SBD	School-based deworming
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations Children’s Fund
WaSH	Water, Sanitation and Hygiene
WHO	World Health Organization

ABSTRACT

Soil-Transmitted Nematodes (STNs) are roundworms transmitted through faecally contaminated soil. Globally, major STNs include *Ascaris lumbricoides*, *Trichuris trichiura* and hookworm (*Necator americanus* and *Ancylostoma duodenale*). School going children are mostly affected by STN infections. STNs cause malnutrition, intellectual retardation and cognitive deficits. They are distributed worldwide, Kenya included and they are of public health importance. Kenya has embarked on mass deworming programs since 2012.The study is entrenched in school mass deworming programs. Kakamega county has high edemicity of STNs and treatment using albendazole has been going on since 2009. The main objective of the study was to determine the effectiveness of a single 400 milligram dose of albendazole against STNs infections. A longitudinal study was conducted in selected public primary schools selected through random sampling from three randomly selected sub counties, Kakamega East, Kakamega Central and Kakamega South in Kakamega County, in Kenya. A structured checklist was used to establish demographics of the school pupils and schools' WASH conditions. Kato Katz technique examined STN infections both at baseline and follow up survey. The prevalence of infection was determined as the percentage of children that tested positive for each STNs species to the total number of children examined. Intensity of infection was determined using Arithmetic mean of the number of eggs per gram of feaces. A total of 731 children in baseline from seven primary schools provided stools and were examined for STN infections. A post treatment survey was conducted after two weeks where total of 665 children were examined. Effectiveness of albendazole was analyzed using prevalence reduction and the fecal egg reduction rate (ERR). Data was analyzed using STATA version 12.0. Associations were assessed between WASH predictors and STNs; Infection prevalence of either gender or age group was analysed using Pearson chi-square test. Infection mean intensity was assessed using two sample independent t- test and significance for age group was assessed using ANOVA test. Prevalence of infections based on 95% CIs was calculated using binomial logistic regression. Arithmetic mean expressed mean egg counts and negative binomial regression model estimated mean intensity. At baseline, STNs prevalence was 44.0% (95% CI: 35.8 – 54.2). Common STN was *Ascaris lumbricoides*. 43.5%. The baseline STN mean intensity was 3674 eggs per gram. There was significant prevalence reduction of combined STN prevalence infection to 2.3% (PR=94.9%, P=0.001). STNs mean intensity was significantly reduced from 3674 epg to 59 epg (ERR=98.4%, P=0.001). Prevalence of *T. trichiura* significantly reduced, 0.8% to 0 (100%, P<0.001). Pupil latrine ratio was significantly associate with STN infection intensity (χ^2 = 3.7333, df=1, p=0.047).Imroved water source was not significantly associated with both lower infection prevalence (χ^2 = 0.875, df = 1, p=0.350) or intensity (χ^2 = 0.1944, df = 1, p=0.659). Hand-wash facility with water and soap did not associate with both lower infection prevalence (χ^2 =0.4667, p=0.495). In this study, mass treatment with Albendazole was highly effective on the STNs. These findings are important to Ministry of Health and Ministry of Education in assessing the national deworming guidelines and policies. Mass Deworming programmes be extended to communities to ensure all possible transmission focal points are covered.

CHAPTER ONE: INTRODUCTION

1.1. Background Information.

Nematodes are long cylindrical unsegmented worms of which some are free living while others are parasitic to man. Among the human parasitic nematodes, six of them are classified as gut dwellers or intestinal nematodes which include *Ascaris lumbricoides, Trichuris trichiura (Ancyslostoma duodenale* and *Necator americanus*), *Strongyloides stercoralis,* and *Enterobious vermacularis* (Blackburn, 2016). The parasitic nematodes that infect tissue are *Trichnella spiralis, Dracunculus medinensis, Onchocerca volvulus* and *Loa loa. Wuchereria bancrofti* and *Brugia malayi* are common blood and lymphatic dwellers (Leung, 2017).

Soil Transmitted Nematodes infestation is a global health problem with more than 2 billion people in the world infected. Sub Saharan Africa, South Asia and South America have the highest level of infection in the world (WHO, 2015). This forms over 24% of world population infected with STNs worldwide (WHO, 2013). Kenya records an approximate of 10 million people infected with STNs with an estimated 12 million remaining at high risk and confined in the poor and impoverished rural areas (Clements *et al,* 2010).

World health Assembly advocated that countries with high endemicity of STN need to address the problem through mass anthelminthic administration and access to safe water, improved sanitation and health education promotion practices such as handwashing and wearing shoes (WHA.54.19, 2001). Kenya, in response to WHO recommendation, therefore, rolled out the National School Based Deworming Programs (NSBDP) in 2009 under school health policy through the Ministry of Education Science & Technology

(MoEST) and Ministry of Public Health and Sanitation (MoPHS) (National School Health Policy, 2009). The National parasitic intestinal worm burden then, was 56.8% (Kabaka *et al*., 2011). More than 280 million children in Africa required deworming (WHO, 2012). School children have the highest worm burden that cause iron deficiency, malnutrition and cognitive and physical impairment (Pullan 2010). In 2012, Kenya initiated school deworming for a period of five years (Mwandawiro *et al.*, 2013). Regions with high endemicity were identified. These included coast, Rift Valley, Nyanza and Western regions (Evidence Action, 2015). Since the initiation of Kenya National School Based programme (KNSBP) using albendazole in 2012, Soil transmitted nematodes elimination as a public health problem has continued to persist in Kakamega County (KNSBP, 2013). Prevalences have remained significant despite the deworming programme (Jia *et al.*, 2012). Scaled up monitoring of drug effectiveness become necessary to prevent the spread of resistant worms (Vercruysse, *et al.,* 2008).

Water Sanitation and Hygiene (WASH) education practices play an important role in performance and health of school aged children (UNICEF, 2012). Sustainable WASH practices promote hygiene, increases accessibity to quality education and advocates for safe water and basic santation interventions in schools (UNICEF, 2012). Kenya enacted School Health Policy, School Health and Guidelines in 2010 with the aim of improving WASH intervention health programmes with full participation of school children as the agent of change (MoPHS/MoE. (2009). Eradication of STNs need targeted integrated preventive chemotherapy, and improved WASH conditions to break transmission cycle especially in areas of high endemicity (Cha *et al.*, 2019). It has been observed that school environment with proper hygiene, achieved by appropriate hygiene practices, availability of safe, adequate water supply and adequate improved sanitation have reduced intestinal worm infestation and diarrhea (Ministry of Public health, 2009).

1.2 Statement of the Problem

Kakamega County is among the areas with high endemicity of STNs (Pullan *et al.* (2011). The county annual health report of STNs indicated a prevalence of 27.2% (Kakamega county Health Annual Report, 2013). Despite previous rounds of deworming, prevalence rate of STNs as high as 31.4 % are still being observed indicating that these infections remained significant in the region despite chemotherapy (Mwandawiro *et al.* (2013). Studies indicate that there has been antihelmthic drug resistance in livestock due to high frequency of repeated mass deworming of the herd (Schwab *et al.* 2005; Schwenkenbecher *et al.* 2007). Frequent deworming of school children in Kakamega county using albendazole has resulted to varied prevalence reduction similar to what is demonstrated in veterinary Soil Transmitted Nematodes (Wolsthenholme *et al.,* 2004; Pullan *et al.*, 2011).

There is high risk of reduced effectiveness of BZ drugs in Kakamega which could be due to frequency of chemotherapy through MDA, though this has not been fully established (Levecke *et al.,* 2014). Several factors may be contributing to this observation one of which could be drug pressure due to the frequent use of albendazole in mass treatment of children infected with STNs in Kakamega causing drug tolerance of the worm in human host. The use of deworming drugs for many years to control livestock nematodes has resulted in emergence of significant levels of resistance (Prichard *et al.,* 2008). Studies on effectiveness of albendazole on STNs have also given varying results suggesting there could be reduced efficacy (Diawara *et al*., 2009; Kotze *et al*., 2011, Diawara *et al*., 2013).This indicate effectiveness of albendazole is questionable and not all soil transmitted nematodes have been responsive to this drug (Diawara *et al*., 2013; (Humphries *et al*., 2011). There is need to monitor the effectiveness of the drugs used in treatment of helminthes in human. Reduced effectiveness in treatment for nematodes using a single dose drugs in humans should be taken as early signs of resistance in order to address the problem in due time.

WASH conditions within schools are the main cause of parasitic diseases (Barasa *et al.*, 2015). Many schools in Kenya were indicated to have very poor water and sanitary facilities (UNICEF, 2009). Some absolutely lacked latrines and had insufficient safe water for drinking and hygiene that led to school absenteeism and high drop-out rates among pupils ((UNICEF, 2009). Parts of Kakamega County indicated 10% coverage of piped water with 97% of households still using pit latrine (MoPND, 2004). The effect of these two factors on the transmission of STNs within Kakamega County have never been investigated.

1.3 Justification of the study

In Kakamega County, morbidity, prevalence and intensity of STNs remain varied despite the regular deworming programme. Global Atlas for helminthic Infections documented a high transmission of STNs in Kakamega County (GAHI, 2015). Kakamega County is among the areas with high endemicity of STNs (Pullan *et al.*, 2011). Determining the effectiveness of the albendazole drug, there was need to evaluate an area with relatively high infection levels (Pullan *et al.*, 2011). Despite previous rounds of deworming, prevalence rate of STNs as high as 31.4 % are still being observed indicating that these infections remained significant in the region despite chemotherapy (Mwandawiro *et al.*

(2013). Several factors may be contributing to this observation one of which could be drug pressure due to the frequent use of albendazole in mass treatment of children infected with STNs in Kakamega causing tolerance of the worm in human host. In recent years, several reports of apparent failures in the treatment of human schistosomes and nematodes have been reported (De clercq *et al.*, 1999; Hu *et al.*, 2013).

Also, drug resistance has been observed in livestock host and to every anthelmintic class (Geerts and Gyreseels, 2000). In some regions of world, the extremely high prevalence of multi-drug resistance (MDR) in nematodes of sheep and goats has threatened the viability of animal agriculture. Resistance in nematodes of horses and cattle has not yet reached the levels seen in small ruminants, but evidence suggests that the problems of resistance, including Mult-Drug-Resistance worms, are also increasing in human hosts (Vercruysse *et al.*, 2008). There is therefore an urgent need to monitor the effectiveness of chemotherapy in relation to drug resistance in nematode worms in Kakamega County particularly now that effort to control and eventually eradicate worms in human population through MDA are being carried out in Kenya.

Another strategy being used to control the problem of STNs is the implementation of WASH conditions in schools in the study area. Most studies that estimate the relationship between WASH and STNs have focused only on household domestic situations, disregarding other possible environs that could harbor these infections, such as schools (Strunz *et al*., 2014). Since childen spend most of their time in schools, it is possible that most infections will occur in school therefore the need to establish the WASH conditions in school and their impact on the transmission of STNs.

1.4 Research Questions

(a). What is the pre-treatment prevalence and intensity of STNs in school going children in Kakamega County, Kenya?

(b). What is the post-treatment prevalence and intensity of STNs in school going children in Kakamega County, Kenya?

(c). What is prevalence and egg reduction rate of STNs using Albendazole in school going children in Kakamega County, Kenya?

(d). What are the school WASH conditions in the study area?

1.5 Null Hypotheses

(a). There is no difference between pretreatment and post- treatment prevalence of STNs among school going children in Kakamega, County

(b). There is no difference between pretreatment and the post- treatment intensity of STNs among school going children in Kakamega, county

(c). Albendazole is not effective on STNs infections among school going children in Kakamega, county

(d). School WASH factors are not associated with prevalence and intensity of STNs infections among school going children in Kakamega, county

1.6 Main Objective

To determine effectiveness of albendazole on treatment of Soil Transmitted Nematode among school going children in Kakamega County, in Kenya.

1.7 Null Hypotheses

(a). There is no difference between pretreatment and post- treatment prevalence of

STNs among school going children in Kakamega, County

(b). There is no difference between pretreatment and the post- treatment intensity of STNs among school going children in Kakamega, county

(c). Albendazole is not effective on STNs infections among school going children in Kakamega, county

(d). School WASH factors are not associated with prevalence and intensity of STNs infections among school going children in Kakamega, county

1.8 Assumption of the Study

When sampling study subject assumption was made that information on age was accurate. Where children were not able to give the right age, class and admission registers were used to obtain the correct information on the year of birth. The children were given anthelminthic drug (albendazole) under strict observation. It was assumed that all adhered to the instructions given.

1.9 Conceptual Framework

The conceptual framework was developed drawing on a range of different demographic parameters that influence the prevalence and intensity of STNs such as age and gender. The STNs infections varies with age and reaches the peak between 5-15 years (WHO, 2016). Schools are existing structural points for deworming exercises providing easy promotion of improved sanitation, handwashing, and hygiene education practices. This framework was used to determine prevalence and intensity of STN in different age categories in school age children. The schools were used to identify school WASH factors that contribute to STN infections such as school water source, handwashing habits, latrine condition and sanitation. Treatment using albendazole was used as intervention to lead to sustained interruption of STNs transmission. Prevalence reduction rate and egg reduction rate were used to determine effectiveness of albendazole (Fig 1.1).

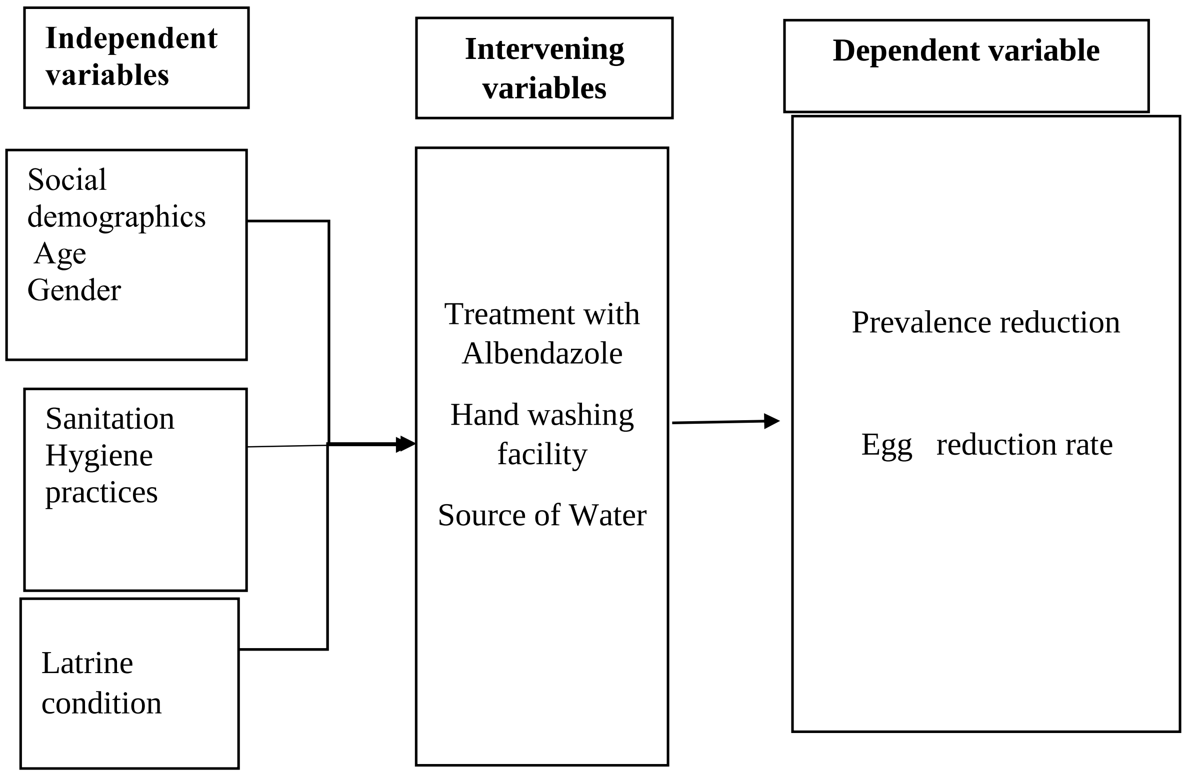

Fig 1.1. Conceptual Framework. (Brooker *et al.*, 2015)

CHAPTER TWO: LITERATURE REVIEW

2.1 Soil Transmitted Nematodes

Nematodes are roundworms that belong to Phylum Nematoda. They are cylindrical worms that are either free living while others are parasitic. Human- parasitic nematodes include *Ascaris lumbricoides*, *Ancylostoma duodenale* and *Necator americanus, Trichuris trichiura, Trichnella spiralis, Strongyloides stercoralis, and Enterobius vermacularis.* Soil Transmitted Nematodes (STNs) are parasitic nematodes (intestinal worms) whose some of the life cycle stages pass through contaminated soils. They cause the frequent human parasitic diseases that include ascariasis, strongyloidiasis trichiuriasis, ancylostomiasis, and necatoriasis (Takafira *et al.*, 2017).

The most common STNs are *Ascaris lumbricoides*, *Ancylostoma duodenale* and *Necator americanus* (hookworm) and *Trichuris trichiura* (whipworm). Soil-transmitted nematodes infections occur mainly in the regions of moist, warm climates and in temperate zones that have poor sanitation and hygiene especially in warmer months (CDC, 2013). They live in the small and large intestine of infected persons and their eggs are deposited in soils along with feces. Soil Transmitted nematodes eggs mature in the soils and become infective. Transmission occurs through ingestion of infected eggs with (*Ascaris* and whipworm). This occurs when one comes into contact with contaminated soils, food and water. Hookworm transmission occurs when infective larvae penetrate human skin (Blackburn, 2016). *Ancylostoma duodenale* transmission can also occur through oral ingestion of the larvae. Light soil-transmitted helminth infections are asymptomatic. People with heavy infections can cause a range of health problems, including abdominal pain, diarrhea, blood and protein loss, rectal prolapse, and physical and cognitive growth retardation. In the intestines they feed on the food nutrients and blood from intestinal mucosal wall making the human host prone to malnutrition and anaemia (CDC, 2013; Blackburn, 2016).

2.2 Global distribution of Soil Transmitted nematodes

Infections in human by parasitic soil transmitted nematodes include ascariasis, hookworm (necatoriasis ancylosotomiasis) trichuriasis, enterobiasis, strongyloidiasis, filariasis, trichinosis among others. Ascariasis causative agent is *Ascaris lumbricoides* (roundworm). It is worldwide and the most common infection in man especially in the tropical countries. The worldwide estimated prevalence of ascarisis was1 billion people (Murray, 2017). Dori *et al.* (2011) and CDC (2013) documented that an approximate of 550-750 million people are infected with *Ancylostoma duodenale* and *Necator americanus* human hookworm.

Trichuriasis is caused by *Trichiuris trichiura* (whipworm) and is most prevalent in warm climates in the world. Enterobiasis is caused by pinworm. *Enterobias vermacularis* has high prevalence in children of the world temperate countries. In some world regions, an estimated prevalence of 4–28% in children has been reported (Murray, 2017). Strongyloidiasis is parasitic infection caused by *Strongyloides stercoralis* (threadworm) whose infection is more prevalent in regions with poor sanitation especially in parts of Africa and Southeast Asia. Strongyloidiasis has a worldwide estimation of 30-100 million people infected (Murray, 2017). Trichinosis is world distributed and is caused by *Trichinella spiralis*. It has been reported as a major public health problem spread both in carnivorous animals and human beings. It is prevalent in Asian countries, such as

Japan, China, Thailand and Korea (Murray, 2017). Onchocerciasis is caused by *Onchocerca volvulus* filarial worm that cause river blindness disease. It is a common parasitic nematode that infects 20 million people East, West, and Central Africa and 1 million in Central and South America (Murray, 2017).

Globally, nematodes form the most gastro- intestinal parasites with children having highest infection rates especially in sub-Saharan Africa (SSA), Asia and Latin America and the Caribbean (LAC) respectively (Pullan *et al.*, 2014). In addition, in North America and Europe, gastro intestinal parasites infections are found in area of intense poverty within refugee and immigrant communities (Hotez *et al.*, 2009). Approximately 2 billion people in the world are infected with STNs (WHO, 2012; WHO, 2016). The infections begin when their eggs or larvae are released in the soils. According to Bethony, (2006) and Campbell, (2014), the chief STN infections occur among school-aged children, living in poor established conditions with poor inadequate sanitation facilities and lack of clean water.

The highest numbers of these parasites are broadly spread in America, China, East Asia and Africa Sub-Saharan regions (WHO, 2016). The population at higher risk with these chronic STNs infections are pre- school, school going age children, women of childbearing age especially pregnant and breastfeeding women (WHO, 2012, 2017). Transmission of STNs is intensive especially in preschool age and school age children with more than 270 million and 600 million of them infected (WHO, 2016).These groups are more vulnerable and experience heavy worm burden than any other in the human populations (UNICEF, 2002). *Ascaris lumbricoides*, *Trichiuris trichiura*, *Necator* *americanus and Ancylostoma duodenale* infections occur in adults as well (Campbell, 2014). People infected with STNs infections require frequent preventive measures and treatment especially in areas where transmission is widespread (WHO, 2016).

Children with persistent untreated soil transmitted nematodes infections experience cognitive and physical impairments, anemia and malnutrition (Bethony. 2006). Control of morbidity in school children is the approach currently executed through the use of anthelminthic drugs before diagnosis as the main preventive measure to restrict more transmission of these parasites (Hotez, 2007). Pullan *et al.* (2014) indicated soil-transmitted helminthiasis infections cause an approximate of 5.3 million disability-adjusted life years.

*Ascaris lumbricoide*s causes human ascariasis. It is the largest intestinal roundworm. The parasite has a cosmopolitan distribution with Asia, Africa and Latin America having the largest share of the disease (O'Lorcain & Holland, 2000). Since over more than 1 billion people are infected with this parasite, there is a loss of over 10 million DALYs worldwide (Bethony *et al*., (2006); Hotez & Kamath, (2009). There are two hookworm nematodes species that cause disease in humans namely *Ancylostoma duodenale* and *Necator americanus* both of which have a worldwide distribution. An estimate of about 1.3 billion individuals are currently infected with hookworm with about 65,000 million deaths annually (Supali *et al*., 2010). Human trichuriasis is caused by *Trichuris trichiura,* a nematode commonly known as whipworm. According to Bethony *et al.*, (2006) trichuriasis disease is widespread in moist warm tropical regions worldwide. An approximated 800 million people have trichuriasis worldwide. Infection rates of up to 75% have been observed in school going children in Puerto Rico.

2.3 Soil Transmitted Nematodes Distribution in Africa

In Sub-Saharan Africa, *Ascaris lumbricoides* parasite infects over 173 million people, mainly school-age children, resulting about 2.2 million DALYs lost to the infections (Bethony *et al.*, 2006). In total, *Ascaris lumbricoides* infections are estimated to result in over 60,000 deaths (WHO, 1998). Hookworm human disease had an estimation of about 1.98 billion individuals, including 40 - 50 million school going children. This makes a loss of about 7.5 million DALYs in the region against a global estimate of 22.1 DALYs (Hotez & Kamath, 2009). Human trichiuriasis has an estimate of 162 million people infected and residing in sub-Saharan Africa (Hotez & Kamath, 2009). It has been estimated to account for a loss of nearly 1.7 million DALYs in Sub- Saharan Africa and 6.4 million in the world. (Supali *et al*., 2010; Hotez & Kamath, 2009). *Trichuriasis* disease is common and affect over 46 million individuals. The greatest number of these individuals are children of Africa, with over 10,000 deaths annually (WHO, 1998).

There has been evidence of several efforts used to control STNs as a public health problem in Africa since early 1913 when attempts to examine and treat all infected primary and secondary school children against hookworm infection in Egypt were made (Davis, 2000; WHO, 2002). Since then, Soil Transmitted Nematodes infections have remained a major health concern and constitutes an important public health problem especially in many parts of Africa (Pullan *et al*., 2014). Soil transmitted infections in children of school age category in Africa was assessed through Remote Sensing (RS) and Geographical information system (GIS) (WHO, 2006). About 89.9 million school-aged children had one or more STN species in Africa in 2005 (Brooker *et al.*, 2006). Prevalence of 44% of STNs infections occurred in four countries namely Nigeria, Democratic Republic of Congo, South Africa and Tanzania (Brooker *et al*., 2006). In Cameroon, estimates of STNs prevalence was 18% in the adults and they become the source of transmission (Jean *et al.,* 2016).

Efforts to reduce STN infections alone are hampered by inadequate supply of anthelminthic drug compared to Lymphatic filariasis and onchocerciasis (Tchuem Tchuenté, 2011). Findings from WHO Regional Committee for African in Rwanda underscored that less than 10% of school children received anthelminthic drug far much less to reach the WHO's target of 75% of school children at risk (Tchuem Tchuenté, 2011). Different geographical regions give variations in prevalence of STNs in Africa. In Nigeria overall prevalence of STNs infections was 30.3% with hookworm being the predominant geohelmith, (Kelechi *et al*., 2015).

2.4 Distribution of Soil Transmitted Nematodes in Kenya

The presence of Soil Transmitted Nematodes in Kenya varies as evidenced from different studies in various regions within the country. The high rate of transmission has led STNs to still remain a major public health challenge. Several studies indicate that despite the frequent chemotherapeutic intervention and policies, considerable sustained level of prevalence are still observed from as low as 4.8% in Webuye, Obala, *et al*, (2013), 35.8% in Marani, Kisii county (Nyakang'o *et. al*, (2015), 40.7% in Nairobi, Kibera slums (Davis *et. al*, 2014), 27.6% Western Kenya, Kepha *et. al*, (2015), and 68% in rural Nyanza ; Riesel *et. al*, (2009) among others. In central Kenya, a study conducted by Muiruri *et al.* (2016) found the overall prevalence of intestinal worms was 12% and 16.5% in intervention and control groups of schools respectively. According to Sakari *et al.* (2017) in Mwea Kenya, the prevalence of *Ascaris lumbricoides, Ancylostoma duodenale* and *Enterobius vermicularis* was 3.3%, 0.83%, 0.6% respectively. Mass Drug Administration is recommended once a year to all at-risk people in areas where these infections are widespread. This is if the prevalence in the community infections is beyond 20% but below 50% and two times a year if it is above 50% (WHO, 2015). Previous studies indicate that STN infections are widely distributed throughout the country from Western to Coastal Kenya where they have been associated with considerable anaemia among the residents (Koukounari *et al*, 2008; Brooker *et al,* 2009).

Soil Transmitted helminthiasis negatively suppress nutritive status and affect intellectual development in children (*Hall et al.,* 2008). Among world countries with high STNs endemicity, 166 of them, according to (WHO, 2012), are targeting to deworm children in schools through deworming control programmes and community control lymphatic filariasis platforms (WHO, 2014). Recommendations by WHO to control helminthiases associated with STNs infections is achieved by advocating public health measures through anthelminthic regular supply of Benzimedazoles in infected regions with over 20% prevalence (WHO, 2006; Gabrielli, 2011). In Kenya, different conducted studies have recorded significant variations between schools in counties. There has been dropping occurrence and intensity of hookworm (*Ancylostoma duodenale* and *Necator americanus)* and *Ascaris lumbricoides* infections between counties (Pullan *et al*., 2014; Nikolay *et al*., 2015).

The most predominate geohelminth infections in humans living in conditions of poverty in underdeveloped world are those that are caused by soil-transmitted nematodes (STNs) and schistosomes (Siza *et al.,* 2015). Disease burden caused by STNs is mostly linked to heavy intensity of infections. An estimated number of 300 million people with heavy

STNs infection experience high morbidity and as a result 150,000 of them die annually (Montresor *et al.*, 2002). Pabalan *et al*., (2018) observed that in terms of effects on health of people, soil transmitted nematodes adversely affects victims' mental growth , lead to decline in educational progress, and hamper economic advancement as well as physical growth. Soil Transmitted Nematodes infections interfere with children learning capabilities due to weakened physical growth, abdominal discomfort and general malaise. This affect their potential to work and achieve their learning abilities (Mascarini-Serra *et al*., 2011).

2.5 Transmission of Soil Transmitted Nematodes

2.5.1 Feacal Oral Transmission

Transmission of STNs is greatly influenced by behavioral and environmental factors that lead to differences in exposure to infections. Human acquire infection of soil transmitted nematodes through ingestion of infective embryonated eggs (WHO, 2016). They are disseminated through feacal - oral route from contaminated soils due to low hygiene practices and sanitation or from contaminated food and water (Parija *et al.,* 2017).

Infections due to *A. lumbricoides* and *T. trichiura* occur through feacal oral route by ingestion of infective eggs. Transmission occurs especially in children when they play in contaminated soils and put their dirty unwashed or improperly washed hands in the mouth. Eggs from contaminated water sources may be ingested and spread the infection. Infection may also occur by ingestion of infective eggs attached to improperly washed, cooked or peeled raw vegetables and fruits (WHO, 2016; Parija *et al.,* 2017). Another study conducted by bethony *et al*., (2006) emphasized that, *Trichuris trichiura* parasitic infections mainly occur in children that get heavily infected and serve as chief reservoirs in their transmission. Its transmission occurs through contaminated water, food or straight from one's contaminated hands.

2.5.2 Transmission through the Skin Penetration

Hookworm infection is acquired primarily by walking barefoot on feacally contaminated soil. *Ancylostoma duodenale* is transmitted both through oral (through the ingestion of larvae) and percutaneous (skin penetration) route whereas *Necator americanus* (hookworms) are acquired percutaneously. Man is the only definitive host with no intermediate host required in transmission of hookworm infection. *Strongyloides stercoralis* (threadworms) are acquired in both oral and percutaneous route. Its transmission occur both in tropical and subtropical countries as well as in countries with temperate climates (WHO, 2018).

2.5.3 Transmission through Inhalation

Enterobiasis *caused* by *Enterobius vermacularis* is transmitted from person to person through infective eggs deposited on perianal area. Airborne transmission is common through inhalation (Cheesbrough, 2011). Autoinfection may also occur because of intense scratching, when infective eggs are transferred to the mouth from hands that may have scratched the perianal fold region. Transmission from person to person contact occur from contaminated beddings and clothings (Cheesbrough, 2011). Contaminated surfaces with pinworm eggs like door knobs, carpets and curtains form transmission focal points.

2.6. Life cycles of Soil Transmitted Nematodes

Life cycles of parasitic nematodes are varied and complex. The human body get infected orally or through skin penetration. Infected individuals with mature adult nematodes release eggs in the feacal wastes. The eggs hatch into larval stages before they mature to adult female and male nematode. According to Blackburn, (2016) complete cycle takes about three months depending on the specific organism. There is no human to human transmission from fresh feaces since the eggs require a three-week period to mature in soil before they become infective. Infections only occur from infectious stages in the environment since worms rarely multiply in the human host (Blackburn, (2016).

The life cycles of Soil Transmitted Nematode fall in two stages. The first stage takes place when eggs are passed from the feaces of human host. In the second stage, eggs mature to infective stage in external environment particularly hookworm larve, *Trichuris trichiura* and *Ascaris lumbricoides* eggs. These infective stages of the parasite in the environment, are the main cause of infections. According to Yadav *et al*., (2003) the life span of these infectious stages takes weeks to months in conducive environmental situations. Infectious material in the environmental habitat is not affected by chemotherapy, it only acts as a reservoir for these parasitic nematodes and poses a challenge in treatment programs implementation.

Enterobius vermacularis, can directly be transmitted from person to person contact., while *Ascaris lumbricoides Trichiuris trichiura,, Necator americanus,* and *Ancylostoma duodenale,* have to pass a soil phase in their development. Frequent intense exposure to the nematode infective larva stages are required to establish the infection unlike the low level of exposure (Blackburn, 2016). *Ancyslostoma duodenale*, and *Necator americanus* hatch eggs in the soil and later release larvae which mature to a form that penetrate the human skin. People who walk bare footed on the contaminated soil become infected with hookworm.

According to Muray (2008), some nematodes have adult worms in definitive hosts where sexual development occurs and larval stages in intermediate hosts where they can be free-living or parasites of invertebrate vectors. Embryonated eggs are released inside or outside the human host body. The eggs may hatch into larva form in the host (*Ascaris lumbricoides T. trichiura)* or in the soils, *(Necator americanus, Ancylostoma duodenale and Strongyloides stercoralis).* In the human host, the larvae become infective in the body *(Ascaris lumbricoides T. trichiura)* or in the soils (*Necator americanus, Ancylostoma duodenale and Strongyloides stercoralis*) followed by penetration through skin. The nematodes take about three months to mature and start to produce eggs which are released in the feacal waste (Muray, 2008).

2.6.1 Examples of life cycles of Soil Transmitted Nematodes

Ascaris lumbricoides and *T. trichiura* life cycle follow feacal oral route through ingestion of food contaminated with fertilized infective eggs. Their life cycle differs in that *T. trichiura* do not follow pulmonary route to the lungs (Murray, 2008). The unfertilized eggs are not infective. The eggs become fertilized within few weeks in warm humid soils. Man is the only host and acquires the infection by taking in eggs with second stage infective larvae from contaminated drinks, raw vegetables, fruits and food. The larvae hatch in the upper small intestine. Once swallowed, the egg shell is softened by digestive juice in the duodenum to facilitate hatching. The enclosed larva hatches out and it is called rhabditiform larva.

The newly hatched *Ascaris lumbricoides* larva burrows through the mucous membrane of the ileum and follow portal circulation to the liver. The larvae enter pulmonary circulation to the lungs where they moult twice and break through the capillary wall to reach the alveoli of the lungs. The larvae crawl up from the alveoli to the bronchi, trachea, larynx and pharynx. The larvae are swallowed once more and passed to the stomach through the esophagus. The larvae later reach the small intestine where they undergo moulting and transform into an adult that become sexually mature (Fig 2.1). The infection is common from man to man. Auto infection may occur in some situation (Blackburn, 2017).

Trichuris trichiura (whipworm) life cycle involves ingestion of embryonated eggs from soil. The life cycle is similar to that of *Enterobius vermacularis* (pinworm) because it does not pass through pulmonary circulation (Murray, 2008). The egg once swallowed, hatch into larva in the upper small intestine and pierces the villus. It continues to mature and pass to the cecum where it lodges in the mucosa of the small intestine. Eggs are released to the soils through defecation and become embryonated in moist soil (CDC, 2000). Adult worms may live in human host for several years (Bethony *et al.*, 2006).

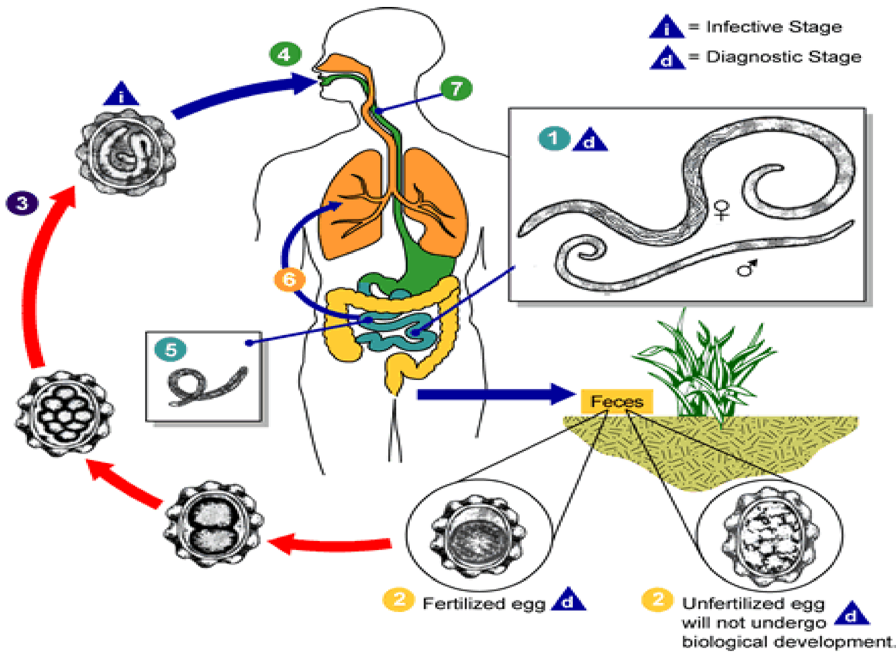

Figure 2.1: The life cycle of *Ascaris lumbricoides* (CDC, 2000)

2.6.2 Life cycle through skin penetration

Humans are mostly exposed to hookworm and *Strongyloides stercolaris* infections, barefooted where filariform larva penetrate the skin exposed to contaminated soils. Penetration occurs at different areas on the skin; most frequently feet and hands. There are two hookworm species namely, *Ancylostoma duodenale* and *Necator americanus*. They differ in that *Necator americanus* has a pair of curved plates anteriorly unlike *Ancylostoma duodenale* that has one or more pairs of teeth. Hookworm's life cycle is similar to that of *Strongyloides stercolaris*, but they differ in that they lack auto-infectious cycle. However, *Ancylostoma duodenale* can cause infection through feacal oral route. Embryo hatches into first stage rhabditiform larva in favourable warm moist soil conditions. The embryos moult to second rhabditiform larva which feed and moult to filariform (non-feeding) larva that is infective stage in soil.

The larva migrate through the epidermis into the subcutaneous tissue and find their way into venules and lymphatic vessels. The larva are carried through the pulmonary circulatory of the lungs. They break into the alveoli, migrate to the respiratory trunk and pharynx (CDC, 2000). The larvae are swallowed to the digestive tract to the upper part of the small intestine. They moult to form the fourth stage larva that attaches to the walls of the small intestines and grow eventually to become an adult (Fig 2.2) (CDC, 2000). The adult reaches sexual maturity, fertilization occurs and female start laying eggs (Blackburn, 2018).

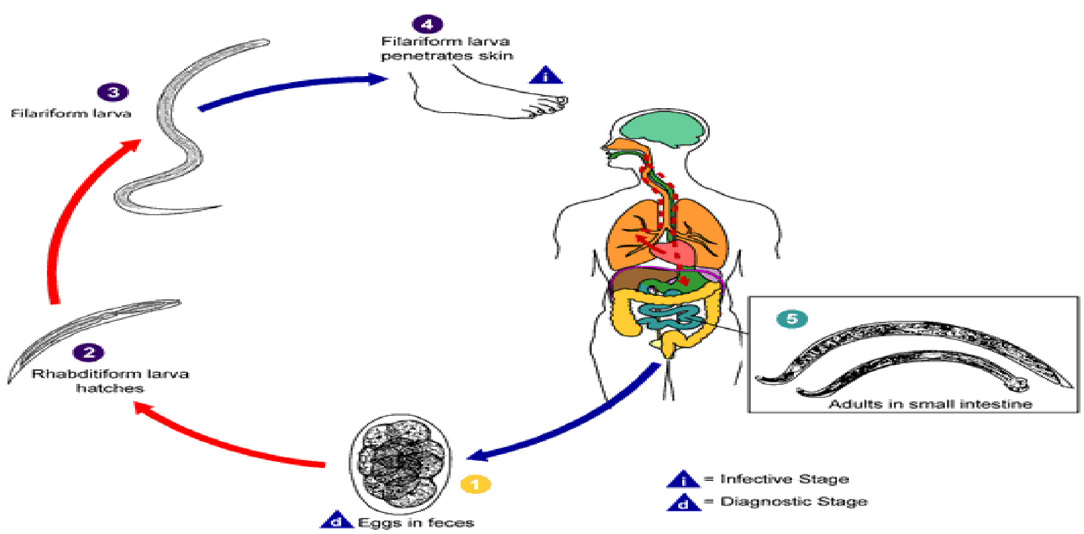

Figure 2.2: The life cycle of hookworm (CDC, 2000)

Strongyloides stercoralis unlike hookworm, exhibit two alternate phases of life cycle that include free living and parasitic cycles. It has unique feature among the helminth because it can be autoinfectious and multiplies within the host (Page *et al.*, 2018). Adult *Strongyloides* produce eggs which hatch to non-infective rhabditiform larvae form which can follow either of the three developmental pathways. The first is autoinfective cycle where the non-infective rhabditiform larvae moult to second stage rhabditiform larvae which further moult to autoinfective filariform. These auto infective forms remain in the host to become parasitic adult females. They live in small intestines and produce more offsprings by parthenogenesis. Autoinfective cycle make *Strongyloides* persistent for decades in the host independent of external environment and with no intermediate host.

The second pathway is the homogonic (direct external) life cycle. This is an exclusive parasitic cycle where the larvae leave human host along with the fecal material to the external environment. The first stage rhabditiform larvae moult to second-stage rhabditiform larvae which become infective filariform. The larvae filariform larvae may survive two weeks in conducive external environment before getting a new host (Jourdan *et al*., 2018).

The third developmental pathway is heterogonic (external indirect) cycle. The larvae is released from the human host through feacal matter, leave the human host via faeces. After four moults, the first stage rhabditiform larvae transform either to free-living rhabditiform adult females or adult males. They mate and the female release eggs which hatch into rhabditiform. They moult like in the homogonic cycle, after they feed on bacteria in the faecally-contaminated soil, to become either infective, non-feeding filariform larvae or free-living adult males (Page *et al*., 2018). Filariform larvae percutaneous penetration the through intact human skin, join pulmonary migration. They are swallowed into the oesophagus, and reach the small intestine where they matures into adult worms. These produce eggs, which hatch and become rhabditiform larvae (Jourdan *et al*., 2018).

2.7 Harmful effects of Soil Transmitted Nematodes in Humans

2.7.1. Anaemia

Anaemia disease is a global public health problem. It is caused by iron deficiency and is associated with STNs infections. Adult hookworm in the lumen of the intestines lacerate the intestinal mucosa resulting in bleeding causing significant anemia, especially iron deficiency anemia (Stephenson *et al.,* 2007). A study conducted in Ethiopia indicated high odds of anemia in children infected with hookworm (Yimam *et al.*, 2016). Another study conducted in the same country found *Ascaris lumbricoides* and hookworm associated with anemia (Molla, 2018). Earlier, Umbreit, (2005) documented on anemia and chronic iron deficiency in young children. Stoltzfus *et al.,* (2003) also argued that both malnutrition and anaemia are heightened by the severity of STN infections and are the responsible for death particularly in children and expectant mothers. Hookworm infection even in light infections, could be linked to higher occurrence of anemia due to lower haemoglobin concentration. Azira *et al.,* (2012) indicated severe chronic iron defiency causing anaemia that required blood transfusion due to Trichiuris dysentery syndrome (TDS) in a Malaysian girl. Abdulhamid Ahmed *et al.,* (2012) observed that ascariasis influences the nutritional status, though its effect on anaemia is unclear. He further emphasizes the strong association between moderate-to-heavy ascariasis and anaemia detected among Malaysian children, could be attributable to the heavy intensity of infections and other contributory factors such as intake of poor diet and poverty. *Trichuris trichiura* cause, iron deficiency anaemia and finger clubbing (WHO, 2002; de Silva, 2003).

2.7.2 Micronutrient deficiency

World Health Organization, (2012) indicates that soil-transmitted nematodes infections affect people nutritional status in a number of ways. First, they feed on host tissues and blood causing loss of protein and iron. These parasitic worms cause nutrients malabsorption in the host body. In addition, *Ascaris lumbricoides* takes vitamin A in the intestine and other substances that change storage and the metabolism of other essential nutrients like iron. Some soil-transmitted nematodes cause decreased nutritional intake affecting physical growth, child weight and fitness due to loss of appetite (Croke *et al.*, 2016). According to Yap. (2014), nutritional deficiency attributed to soil-transmitted nematodes is acknowledged to contribute significantly to reduced growth and physical development.

2.7.3 Blockage of Biliary and Intestinal obstruction

Soil Transmitted Nematodes larvae and adult cause considerable host tissue inflammation and obstruction during larval migration and development. They lodge and encyst within tissues causing lesions and granuloma formation (O'Dologhue, 2010). When the intestinal environment becomes unfavorable, like in obstruction and inflammation, the *A. lumbricoides* adult worms can move to less hostile parts, leading to complications such as biliary obstruction, liver abscess, acute appendicitis, pancreatitis, intestinal perforation, and granulomatous peritonitis (O'lorcain *et al.*, 2000).

Large numbers of Soil Transmitted Nematodes may form a bolus and cause intense and immediate ill health status in children like malnutrition, anemia and intestinal obstruction and blockage (Olack *et al.*, 2011). This causes immediate ill health status in children like malnutrition, anemia and intestinal blockage (Olack *et al.,* 2011). Large numbers of adult worms may enter and cause blockage of small orifices (Blackburn, 2017). Migrating adults worms have been vomited as they wander through different in areas in the host body. They may exit through the mouth, nose, lacrimal glands, umbilicus, and anus. They can pierce through the intestines and reach the peritoneal cavity, the urethra, respiratory tract, placenta and vagina (Blackburn, 2017). Deaths results from STN as a result of *Ascaris lumbricoides* heavily infecting children below ten years causing pancreatic and /or biliary disease.

Strongyloidiasis manifestation leads intestinal obstruction, vomiting, respiratory failure and pneumonitis. Occurrence of hyperinfection syndrome in the host leads to the presence of numerous larvae in the intestines and lungs. The larvae can reach the central nervous system causing brain abscess and meningitis. The spread of larvae is rapid, and may invade cerebrospinal fluid or tissue (Blackburn, 2016). Dermal infection show local erythema, macules, papules (ground itch) due to cutaneous invasion and subcutaneous migration of larva.

Enterobiasis is characterized by pruritis on the perianal skin and obstruction associated with appendicitis. *Trichuris trichiura* cause inflammatory reaction in the hosts' intestine. This is caused by the anterior end of the adult *Trichuris trichiura* entrenched in the epithelial tunnels of the intestinal mucosa (Stephenson *et al.*, 2000b).

2.7.4 Malabsorption and Nutritional effects

Soil transmitted nematodes infections affect nutritional status of those infected. The infections lead to loss of appetite which reduce nutritional intake impairing physical fitness (Crompton 2002). The STN infections cause malabsorption and food indigestion that increase nutritional stress (Crompton 2002). *Ascaris lumbricoides* infection lead to host malnutrition, reduced micronutrients and vitamin A absorption, probably by causing a structural abnormality of the mucosa in the small intestine (Hotez *et al*., 2006; WHO 2019). Heavy infections with *Ascaris lumbricoides* have also been associated with significant malnutrition, especially in children (Bethony *et al*, 2006). Growth retardation and lower body weight due to STN infections have previously been assessed by taking anthropometrical measures using a stadiometer for height and weighing scale for weight (Koukounari *et al.*, 2008). Firmansyah *et al*. (2001) found intestinal nematode interfered with absorption of carbohydrate in Indonesian children. Hookworm infections cause enzymatic damage to the intestinal mucosa which may interfere with absorption resulting to malnutrition (WHO, 2018).

2.7.5 Abdominal Discomforts

Ten to twenty soil transmitted nematodes may go unnoticed except in a routine stool examination. The commonest complaint is vague abdominal pain. In more severe cases, the patient may experience listlessness, weight loss, anorexia, distended abdomen, intermittent loose stool and occasional vomiting. Gastro-intestinal infection from soil transmitted nematodes cause anorexia, epigastric pain and intestinal hemorrhage. This is common with *Ascaris*, hookworm and *Strongyloides* infections (Blackburn, 2016). Hyperinfection in Strongyloides becomes fatal because it reduces the normal immune responses. This may lead to dysentery and rectal bleeding. (CDC, 2000). *Trichuris trichiura* infections are determined largely by the worm burden; less than 10 worms are asymptomatic. Heavier infections (massive trichuriasis) are characterized by chronic profuse mucus and bloody diarrhea with abdominal pains, oedematous prolaspsed rectum and tissue necrosis (WHO, 2002; Silva, 2003).

2.7.6 Socio economic effects

Ascaris lumbricoides, hookworm and *Strongyloides stercolris,* cause iron deficiency. According to Haas *et al*., (2001) iron deficiency anemia reduce work capacity of infected people. Anemic and stunted children with soil transmitted nematodes infection suffer ill health that cause long term impacts on productivity in adult life (Morgan, 2018). Such children may physically be deprived in the labour force or indirectly get low earnings in future because of low education achievement (Baird, 2016). According to Drake *et al*., (2000) *Ascaris lumbricoides* play a significant role in childhood malnutrition, which leads to growth retardation, cognitive impairment, and poor academic performance. This results to poorer quality of life and less ability to contribute to society.

The STNs infections reduce development of individual productivity that prevent economic growth of individual and society (Ozier, 2018). A study done in India indicated disability risk was associated with *Ascaris lumbricoides* and *Trichiuris trichiura* infection in 5-15-year age group (Parija *et al.,* 2017). This affect productivity later in adult life (Guyat, 2000). Soil transmitted nematodes infection cause heavy burden of disease and contribute to DALY lost (Parija *et al.,* 2017). Disability of adjusted life years is an indicator that measure equivalent loss of one year (Murray, 1996).

Diseases by STNs have a negative impact on socioeconomic due to hospitalization cost and treatment of DALY (Utzinger, 2004). Over 10 million DALYs worldwide are lost due *Ascaris lumbriocides* infection (Hotez *et al.,* 2009). Another conducted study indicated that hookworm infections led to estimated 1.6 million DALYs that amounted to US$139 billion annual productivity loss (Hay et *al.,* 2017). Deworming children has 32-52% rate of return to the government (Evidence Action, 2015). Adult treated as children had more work out put per week, high likelihood to be in high wage jobs and could spent more time in entrepreneurial skills (Evidence Action, 2015).

2.7.7 Cognitive effects on children

Soil transmitted nematodes lead to impairment of cognitive function (Gordon *et al*., (2003). According to Quihui *et al.,* (2004) and WHO (2018) infections by STNs cause detrimental effects on development and growth of affected person. Soil transmitted nematodes are associated with childs' immune function, poor school performance, retarded physical growth, cognitive and intellectual development that lead to increased child mortality (Pabalan, 2018). *Trichuris trichiura* is associated with reduced cognitive abilities in children (WHO, 2018). According Hall *et al.,* (2008) STNs infections negatively impair nutritional intake and cognitive capacity.

2.8 Diagnostic Techniques of Soil Transmitted Nematodes

Right diagnostic method is important for clinical and public health purpose on examination of Soil Transmitted Nematodes. The diagnostic technique depends on the parasite being investigated**.** All the methods vary in quantification of eggs which is an important aspect of treatment evaluation and establishment of intensity of infection (Nikloy *et al*., 2014).

2.8.1 Clinical signs of Soil Transmitted Nematodes

Children with *Ascaris lumbricoides* infections experience inflammatory and hypersentive reactions. They experience attacks of bronchial asthma, wheezing cough irregular, nausea and vomiting and severe abdominal pain (Murray, 2016). Light *Trichiuris trichiura* infection are asymptomatic. Heavy infections display distended abdomen, abdominal pain, bloody diarrhea and loss of weight in infected children. Infection with hookworm skin penetrating larvae are responsible to rashes at the point of entry and allergic reactions (Murray, 2016). Patients with hookworm infections experience intestinal symptoms of vomiting, diarrhea and nausea. Migrating larvae in the lungs produce eosinophilia, and pneumonitis (Murray, 2016). Similar to hookworm and Ascarisis infections, strongyloidiasis produce pneumonitis caused by pulmonary migrating larva. Intestinal infections are mostly asymptomatic but may lead to bloody diarrhea and vomiting. Severe epigastric pain that mimics peptic ulcer ailment strongly suggest strongyloidiasis. *Enterobiosis* is detected through itense scratching of perianal fold due to secretions of migrating female worm (Murray, 2016).

2.8.2 Laboratory diagnosis of Soil Transmitted Nematodes

Most of Soil Transmitted Nematodes laboratory diagnosis is by microscopic detection of eggs in the stool (Blackburn, 2017). According to Yimer *et al.*, (2015) several parasitological laboratory diagnostic technique are suitable for STNs diagnosis. They include direct smears, formal ether and Kato katz technique. Soil transmitted nematodes require appropriate diagnostic tools because of their importance in public health. These nematodes infections may be diagnosed via microscopiy of eggs in direct smear except Strongyloides (Blackburn, 2017)**.** This method is sensitive for examination of *Ascaris* *lumbricoides* because of the high egg output. Diagnosis of *Ascaris lumbricoides, Trichiuris trichiura* and hookworm is by detecting eggs in faeces. Hookworm larvae could be detected in the faeces. Demonstration of *Ascaris lumbricoides* adult worm in faeces particularly after treatment is a direct diagnostic confirmatory evidence of infection (Cheesbrough, 2011).

2.8.2.1 Direct saline technique

Fresh stool sample is used and a pea size amount of stool is placed on a sterilized slide with an applicator stick. The stool sample is emulsified with a drop of saline for semi solid and diarrheic stool. Iodine is used for well-formed stools which is broken down for adequate staining. The preparation is covered with a coverslip and microscopic examination is done. This method is suitable for *Ascaris lumbricoides* due the release of high number of eggs (Yimer *et al.,* 2015).

2.8.2.2 Formal ether concentration technique

The technique involves thorough missing of small amount of feaces with normal saline. The contents are passed through a sieve or two layers of gauze into a centrifuge tube. After adding formaldehyde and ether, the solution is centrifuged at one thousand revolutions to form supernatant which is decanted and sediment is left for a few minutes. Sediment is used for the slide preparation using either saline or iodine and covered with a cover slip for microscopy examination (Yimer *et al.,* 2015). For *Trichiuris trichiura* and hookworm formol-ether concentration method is recommended for light infections because of their egg output is not high like for *Ascaris lumbricoides.* In heavy infestations, *Ascaris lumbricoides* larve may be coughed up in sputum or through respiratory secretions (Blackburn, 2017). Zinc sulphate saturation is recommended for concentrating *Trichiuris trichiura* eggs while sodium chloride floatation method concentrate *Ascaris lumbricoides* and hookworm eggs (Cheesbrough, 2011). Other methods have been compared in detection of STNs with simple gravity sedimentation and Wisconsin floatation techniques showing highest intensity (Goodman *et al.*, 2007). When eggs of *Strongyloides stercolaris* are not detected in stools and infection is suspected, larvae can be detected in fresh stools. Duodenal aspirates may be used when the larvae are not detected by direct examination (Cheesbrough, 2011).

2.8.2.3 Quantification of soil transmitted nematodes by Kato Katz Technique

Kato Katz is used to concentrate and quantify feacal parasites. World Health Organization. (2002) support use of double slides Kato Katz technique as method of detecting the presence of parasites ova in stool sample. This technique has many advantages in treatment of helminth infection. First, it is a rapid and low-cost method which is applicable to field situation (Calvopina *et al.*, 2018). Secondary, it measures the amount of eggs in feaces and in addition to this, the total worm burden can be approximated. It allows evaluation of a treatment program in endemic communities by measuring prevalence and intensity of infections (Levecke *et al.*, 2014). In human helminthiasis, determination of Feacal Egg Count (FEC) is largely by the Kato Katz technique but not without shortcomings. Detection and quantification of STNs eggs especially hookworm, is a challenge because they get lysed during processing. The technique is however cheap and easy to perform in field surveys (WHO, 2002).

2.8.2.4 Examination of Perianal eggs by Adhesive tape Technique

Enterobius vermercularis (pinworm) eggs can be detected from perianal skin or from clothings worn at night. Eggs from perianal skin may be found in feaces or occasionally in urine from infected females. A clear adhesive strip mostly cellotape is wrapped to the skin around the anus and eggs are collected. A drop of xylene may be used to clear any debris (Murray, 2016). Several varied diagnostic tools promote the success of a control program by accurately estimating the prevalence and intensity of STNs. This can help make better choices to effect control strategies (Booth *et al.*, 2003).

2.9 Treatment of Soil Transmitted Nematodes

In 2001, a resolution was passed by World Health Assembly, requiring the member states to control the morbidity of soil-transmitted helminth infections. This was through the use of anthelminthic drugs on children in school in underdeveloped countries through periodic anthelminthic administration (WHO, 2018).

The main drugs approved against Soil Transmitted Nematodes by World Health Organisation, (2018), are mebendazole (MBD), albendazole (ALB), levamisole and pyrantel. The best choice of treatment for infections with STNs anthelminthic still remained the benzimidazoles with the exception of Strongyloides (Blackburn, 2017). For roundworm, whipworm, hookworm and pinworm single-dose regimens of albendazole (400mg) is recommended over single-dose mebendazole (500mg) (Blackburn, 2017).

Both Mebendazole and albendazole have high anthelminthic activity. They have varied anthelminthic agents with different level of effectiveness. Saathoff *et al.*, (2004), found that, in Kwa Zulu school children, albendazole satisfactorily treated ascariasis and hookworm diseases but was ineffective against *Trichuiris.* Elsewhere, several doses of albendazole were recommended to clear *Trichuiris trichiura* (Wendelin *et al.,* 2017).

Both albendazole (ALB) and mebendazole (MBD) form benzimedazoles class of anthelminthic periodically used in the treatment of STNs infections and used in public health interventions (Montresor *et al.,* 2002). Bennett and Guyat., (2000) found that both drugs have effectiveness against STNs, but one dosage of albendazole surpasses effect of mebendazole in anthelminthic activity in hookworm infection. These drugs have essential anthelminthic properties but their effectiveness differences vary in treatment of STNs clinically.

In a study from three continent found single dose of albendazole with a higher cure rate and more effective for hookworm treatment (Vercruysse *et al.,* 2011). Further, he observed, albendazole having low cure rate of trichuriasis in a single dosage. The guaranteed benefits of both drugs differ in that mebendazole is lowly absorbed from the gastrointestinal tract and activity against STNs infection is restricted to the adult worms where they can stay for long time (Adam *et al.,* 2002). According to Adugna *et al.,* (2007) there is significant high prevalence reduction and egg reduction rates against *Ascaris lumbricoides* in Ethiopia.

Jia *et al*. (2012) and Appleton *et al*. (2009) indicated that, prevalence of *Ascaris lumbricoides* after treatment with albendazole or mebendazole get back to the pretreatment levels within six to 12 months as compared to hookworm reinfection which has quite slow reinfection rate. *Trichuris trichiura* rate of reinfection has however been difficult to estimate accurately due the low benzimidazoles efficacy against this parasite as recorded by Keiser *et al*. (2008) and echoed by Levecke *et al*. (2012) who said that, this situation occurs especially in cases of high intensity of infection in children. *Enteroboius vermacularis* require single dosage of albendazole (400mg) or mebendazole (100mg) (Blackburn, 2017). Oral ivermectin (200mg daily for 2 days) effectively treat strongyloidiasis disease (Blackburn, 2017).

2.10 Resistance of Soil Transmitted Nematodes to Anthelminthic drugs

Anthelmintic resistance is an indication of reduction in the effect of a drug against a population of parasites which are commonly susceptible to a particular anthelmintic (Shalaby *et al.*, 2013). Anthelmintic resistance occurs, when after anthelmintic treatments, tolerant worms survive. According to a study conducted by Coles *et al*., (2006) resistance from susceptible population show a decrease or no effect in response to treatment even after maximum dosage. Shalaby *et al.* (2013) further indicated resistance include decrease in time a drug treatment exerts its effect.

More sensitive diagnostic methods would also be useful for detecting any development of anthelmintic resistance (Dacombe, 2007). Early detection of the development of drug resistance in human infections will be vital for ensuring that appropriate management strategies are implemented to reduce its spread. This could have important economic consequences for the mass control programs.

In veterinary nematodes, development of possible anthelminthic resistance has been observed (Coles *et al*., 2006). The same might develop in human STNs, though no data indicate the presence resistance alleles in human and in parasite populations. Notwithstanding, already worrying signs indicates that anthelmintic effects are on decline. Appropriate measures require to be implemented to prevent further decline in drug effectiveness (Diawara *et al.*, 2009, Diawara *et al.*, 2013).

Different studies investigate the prevalence and Egg Reduction Rates on (BZ) anthelmintic used against human STNs. These parameters give variations in effectiveness of ALB (Albonico *et al*., 2003; Flor *et al*., 2007; Kihara *et al*., 2007). This could be contributed by the kind of test in the diagnostic methods used in determining the Feacal Egg Count/Egg Reduction Rates, treatment regimens, drug dosages or geographical location.

2.11 Causes of Drug Anthelminthic Resistance

Wolstenholme *et al.* (2004) proposed four ways in which drug resistance can occur. First, it can happen due to metabolism change inactivating or removing the drug thus preventing drug activation; secondly, due drug distribution change preventing its access to organisms' site of action; thirdly target gene amplification preventing drug action and lastly failure in recognition of target by the drug, due change in molecular target. In principle, nematodes can employ a range of strategies to achieve a state of reduced susceptibility towards a given anthelminthic drug. These include the modification of drug target like the binding site, increased target site numbers for instance neuronal receptors, increased transmembrane drug efflux and increased metabolization of the drug.

In general, there are two types of mechanism of drug resistance: Of the two types, specific resistance mechanisms which is resistance associated with changes in the drug target. This would generally be considered as specific mechanism of resistance, since only the respective drug class will be affected. The second is unspecific resistance mechanism which play a role in benzimidazole resistance and macro cyclic lactones resistance (Geerts and Gryseels, 2001). According to Prichard, (2008) it is important to understand the efficiency of anthelminthic drugs in order to overcome resistance, by slowing the spread of parasites. Further, he recommended use of combined anthelminthic drug in order to delay the development of resistance to new anthelminthic drugs, and have improved parasite control (Prichard, 2008).

2.11.1 Under dosing

Inadequate dosage may constitute high risk on the Anthelminthic Resistance development. Under dosing has potential to resistance selection pressure of the heterozygous individuals (Nega *et al.,* 2017). According to Smith *et al.* (1999) under dosing promote drug resistance. Sub-optimal (sub curative) regimens are the rule in human treatment when anthelmintic are given for treatment as a single dose (Vercruysse 2008). This practice is used broadly in mass administration programmes to control helminth in public health. While the operational objectives are laudible it may be disastrous if applied over a long period of time (Nega *et al.*, 2017).

2.11.2 Treatment Frequency and Haphazard use of Anthelminthic drug

Repeated and frequent exposure of Soil Transmitted Nematode populations to anthelminthic drug may develop high potential resistance risks. It has been argued that indiscriminate use of antihelminth without prior diagnosis may develop resistant worms (European Medical Agency, 2016). It is possible develop high risks of drug selection pressure because of same class of anthelminthic drug repeated frequently (European Medical Agency, 2016). Coles, (2005) indicated resistance to broad spectrum anthelminthic drug due to intensive use or use of poor quality drugs whose shelf life had expired.

2.12 Refugia

The proportion of the parasite population unexposed to drugs and escapes selection for resistance is refugia. It is widely overlooked especially on its impact on anthelminthic resistance (Van Wyk *et al*, 2001). Refugia is determined by proportion of population treated either through mass or selective targeted treatments and the proportion of the worm population present in the environment like in the soils where it is not subject to drug action. Climate with other factors affect the longevity of the infective stage of these parasites. WHO (2008) pointed that there is need to understand these factors that affect human STN.

Mass Drug Administration programs should be planned and put in consideration that there are stages of STNs that could be in the environment, in the host and some are seasonally transmitted. This would be vital to maximize the efficacy and reduce the risk of development of anthelminthic resistance. There is large refugia and STN stages widespread during the wet season, in the environment. MDA does not reduce transmission, because it only act against the worms in the host leaving those stages in the environment. During the dry season free-living stages are not numerous in the environment, hence small refugia because most of the parasite population would be in the host.

The control of morbidity in community based on STNs, require timing of treatment programmes for it to be more effective. For MDA to be effective in a community, the best timing would be dry season in order to assess more community participants unlike in wet season when majority would leave early to attend to their agricultural farms making it difficult to be reached for treatment.

2.13 Prevention and Control of Soil Transmitted Nematodes

2.13.1 Treatment of the Infected Individuals

Screening of infected individual is crucial in the control of STNs. This involve selective chemotherapy similar to clinical practice where individual diagnosis is done followed by treatment of infected (Gabrielli *et al.*, 2011). Treatment of the infected individuals reduce the transmission rates of the infection to the populations.

2.13.2 Personal Hygiene

Most of Soil transmitted nematodes in human are fecal - borne infections transmitted hand to mouth through contaminated food, vegetables (green salads) or water. (Cheesbrough, 2001). Washing hands before eating and using soap after toilet visits are important measures that prevent STNs transmission. *Enterobius vermarcularis* (pin worm) infection is controlled through frequent hand washing, regular changes of beddings and nightwear (Blackburn, 2017). Strategies to prevent infected children from scratching perianal, washing and keeping finger nails short reduce transmission particularly in overcrowded poor sanitation areas (Blackburn, 2017). *Ascaris lumbricoides* (roundworms) and *Trichiuris trichiura* (whipworms) infections are prevented through proper hygiene practices of washing hands and use of properly washed vegetables, green salads and fruits. This is because they may be contaminated with feacal material containing infective eggs (Shiferaw, 2015).

2.13.3 Sanitation

Prevention and control of STNs require regular treatment along with long-term preventive measures to interrupt transmission routes and focal points. This is achieved through access and use of a safe and adequate water supply, improved environmental sanitation, and behavioral hygiene habits (Shiferaw, 2015). Proper defaecation practices reduce contamination of environment with infective parasitic worms. The STNs eggs are commonly passed along with faeces, they come into contact with the environment and transform into infective stage. Improved sanitation and hygiene, access to adequate water supply and health education reduce STNs exposure (Shiferaw, 2015).

Feacal contamination is reduced by presence and proper use of latrines and control of feacal soil pollution from untreated human feaces fertilizers. Hookworm and *Strongyloides stercolaris* preventive measures require improved environmental sanitation particularly use latrines and adequate protective footwear to avoid likelihood of contact with infective larvae (Shiferaw, 2015). Hookworm and *Strongyloides* infection are best prevented by avoiding contamination of environment by fecal matter or sewage wastes. Proper sewage disposal and fecal management sanitation systems are keys to prevention (WHO, 2016).

2.13.4 Public Health Education

Health education is important in the prevention and control of all the soil transmitted nematodes. It creates awareness of good personal hygiene, promotes improved behavior and sanitation practices that reduce transmission of infective eggs. The current control programs mainly emphasize on reduction of infection intensity and potential transmission other than eradication, in order to avoid mortality and to reduce morbidity

(Albonico *et al.,* 2008). Prevention measures of soil transmitted nematodes is of public health importance. Reduction in fecal environmental contamination should be used together with mass drug administration. Reduction of soil-transmitted nematodes infections is achieved in the short run and long term means of interventions and elimination. This require proper sanitation and improved behavior in hygiene practices and effective anthelminthic drugs dosage (Steinmann *et al*., 2015). Health education is important in the prevention and control of all the soil transmitted nematodes. It creates awareness of good personal hygiene, promotes improved behavior and sanitation practices that reduce transmission of infective eggs. The current control programs mainly emphasize on reduction of infection intensity and potential transmission other than eradication, in order to avoid mortality and to reduce morbidity (Albonico *et al.*, 2008).

To reduce the burden of diseases caused by STNs, school-based and community control Mass Drug Administration (MDG) programs have been implemented in many endemic countries. Their main goal is to decrease these intestinal parasitic infections to levels at which they cease to be of public health significance WHO (2017; 2018). To control the morbidity and interrupt the transmission of STNs, WHO further recommends three interventions that include a regular treatment of high-risk groups with anthelmintic drugs to reduce the worm burden, then appropriate sanitation to reduce soil contamination with infected human feces and finally health education to increase the population health awareness (WHO, 2018).

2.14 School Based Mass Drug anthelminthic interventions

Chemotherapeutic approaches to treat worms infections have been emphasized WHO. (2018). One of public health intervention to tackle soil transmitted nematodes according to Tylor et *al*. (2009), is through administration of drug to the affected population in the community. World health organization recommend deworming the targeted group without prior diagnosis (WHO, 2017). According to (WHO) 2015 and (WHO) 2018 annual or biannual treatment depending on community STNs prevalence level is recommended.

The main strategy is to target treatment to at-risk groups who range between one to five years (pre-school-age children); between six to fifteen years (school going age); and women of childbearing age. This approach requires an extensive survey on the population to determine the approximate worm burden. This regulates the frequency of treatment, recommended by WHO field manual in 2006 (WHO 2006b). Schools serve as extensive and sustained avenues where deworming drugs can be administered to all school age children in a cost effective, safe treatment strategy (National School Health Policy, 2009).

Leslie *et al*. (2011) showed that school-based deworming programs are cost effective in reducing STN related morbidity.

2.15 Community-based Mass Drug anthelminthic interventions

The community members can be used as distributors of anthelminthic drugs. In such interventions, the entire community is targeted for treatment. The most common is community-directed treatment for onchocerciasis control with ivermectin (CDTI) and mass drug administration for elimination of lymphatic filariasis, either ivermectin+albendazole or DEC+albendazole. In lymphatic filariasis monitoring programme, STN infection in a child, is covered through the administration of a combination of albendazole component. Community directed treatment programme should not use ivermectin since it is not recommended for STN control due to its suboptimal effect against the STN parasites (WHO, 2006). However, the concurrent distribution of albendazole for STN deworming is recommended. The disadvantage of community directed intervention for both onchocerciasis and lymphatic filariasis is that they usually take place once a year, which may not be efficient for STN control. Gabrielli *et al. (*2006) supported that, in case of low school enrolment, community-based distributors are used to treat SAC and other eligible children who are not yet at school.

2.16 Public Health Importance of Soil Transmitted Nematodes

Soil-transmitted Nematodes infections are still neglected and of important public health problem (Yawson *et al.*, 2018). They are common in low and middle income world populations. (WHO, 2016). They are world’s predominant cause of retardation both in intellectual and physical growth (WHO, 2016). They impair cognitive development and contribute to iron deficiency causing anemia (Shrihari *et al*., 2007). Apart from interferences caused in food digestion and absorption that cause nutritional defects, *Ascaris lumbricoides* decrease in absorption of micronutrients and vitamin A. According to Sam, (2012) heavy infestation lead to intestinal and biliary obstruction which lead to death. This further causes an abnormality in structure of mucosa in the small intestine. In addition, hookworm infection contributes to gastrointestinal blood loss, energy deficiencies and micronutrients such as iron, protein and zinc deficiencies, that intensely lead to anemia and malnutrition of which are largely common in women of childbearing age.

According to Bundy *et al.* (1995) maternal hookworm infections are said to affect 44 million expectant women in the world thus posing severe complications during pregnancy and risk of death to the mother and child during delivery. Stephenson *et al.* (2000) observed that *Trichuris trichiura* was responsible for loss of blood, immunological disorders and malnutrition while co-infection of helminthiasis with HIV infection, deteriorates the health of HIV infected persons. According to Ukpai *et al*., (2003) poorly developed countries face severe public health problems caused by Soil-transmitted Nematodes (STNs). These infections constitute a widespread disease burden that affect people socially and economically. These intestinal helminths are responsible for disease hookworm, trichuriasis, and ascariasis diseases among others.

Among the school children, Miguel *et al*. (2003) observed that they suffer stunted growth, retarded physical fitness, cognitive, memory and intellectual capabilities. Baird *et al.* (2011) also found that child health challenges combined affect childhood potential in academic performance and learning abilities thus reducing school attendance. World Health Organization. (2012), further observed that parasitic worms particularly hookworm, reduce future wage earning capacity. World Bank (2003), indicated that, in comparison to all the age groups, school age group records the highest worm intensity. This makes them experience negative consequences in health and nutrition. According to WHO, (2011) in order to reduce STNs infection challenge, expectant mothers and the preschool categories together with the whole community should be included in the mass deworming control programmes.

As a consequence, there has been worldwide initiative to fund endemic areas, through WHO, to have helminth chemotherapy control programs through school infrastructure globally (WHO, 2012)

2.17 Summary

Soil transmitted nematodes have impacted negatively to the health of human populations especially school going children. Deworming programs were initiated by the Kenya government since 2009 (School Healthy Policy, 2009). These has been done through schools without prior diagnosis either annually or biannually depending on endemicity of Soil Transmitted Nematodes. Varying differences of prevalence and intensity of STNs have been witnessed in different studies. Due to frequented exposure to anthemithic drugs there is need to assess prevalence reduction and Egg Reduction Rate to quantify the effectiveness of the deworming drug.

2.18 Gaps in knowledge identified in Literature review

a). Soil Transmitted Nematodes (STNs) infections are of great concern to public health. Their morbidity patterns, distribution and the responsible factors in Kakamega County are not clearly understood making it difficult to effectively control the infections in the area.

b). School deworming programme implementation in as much as it deworms the children in schools, they go home where other family members are not dewormed.

c). According to Mwandawiro *et al*. (2013) Kakamega county had 31.4% despite Mass deworming since early 2012 and no evaluation of the used deworming drug had been done. Mass deworming in children is done frequently without prior diagnosis and this study aimed to find the effectiveness of a drug against identified parasitic nematodes in the area. The quantification of effects of drug on study subjects is of equal importance

d). Kenya implemented National School Health Policy in schools. The study aimed at establishing presence of school WASH conditions and their association with STNs infections

Studies on effectiveness of albendazole on STNs have given varied results suggesting there could be signs of drug failure (Diawara *et al*., 2009; Diawara *et al*., 2013). This study aim to establish possibility of albendazole STNs treatment failure using pre treatment and post treatment findings to assess prevalence reduction and egg reduction rate of soil transmitted nematodes in school children.

CHAPTER THREE: MATERIALS AND METHODS

3.1 Research Design

This was cross sectional study that involved baseline and follow up microscopy examination of STNs. The two surveys were carried out in the year 2014. School children were screened for Soil Transmitted Nematodes according to the deworming programme in baseline survey (pretreatment). Albendazole was given to the school children at the intervention phase. The follow up (post treatment) STNs examination was done fourteen days after treatment.

3.2 Variables

3.2.1 Independent Variables

The independent variables studied covered the study subjects' demographics characters, school WASH health system and latrine structure**.** These were age, gender, sanitation and hygiene factors that included latrine structural condition.

3.2.2 Dependent Variables

The dependent variables were Prevalence reduction rate and egg reduction rate that were determined using infection prevalence and intensity respectively.

3.3 Study Area

The study was conducted in Kakamega County in Western Kenya. The county is located at 00°20'N and 34°46'E with an area of 3,033.8 km (Figure 3.1). Kakamega has a population of, 660,651, based on the 2009 census (Kenya Government 2009). Deworming for STNs often targets children in schools because they are highly at risk.

In a previous study, it was observed that Western Kenya region had the high prevalence (31.4%, Mwandawiro *et al.,* 2013) of the three soil transmitted nematodes (*Ascaris lumbricoides, Trichiuris trichiura* and hookworm) as categorized by WHO criteria (Pullan *et al*. 2011;WHO, 2012).

Kakamega County was classified as a high endemic area in 2009 (Pullan *et al*., 2011). The County was selected because it is a high endemicity area of Soil Transmitted Nematodes (Pullan *et al.,* 2011). School deworming has been going on annually in the Kakamega County as recommended by WHO for areas with 20-50 % prevalence of STN (WHO, 2012; GAHI 2015). Mwandawiro *et al.* (2013) also observed a prevalence of 31.4% of Soil Transmitted Nematodes in the county.

Kakamega County was recommended for annual MDA for the school going children with either albendazole or mebendazole (Pullan *et al.,* 2011). The prevalence of Soil Transmitted Nematodes in the County ranged between 20 -50% (Pullan *et al.,* 2011) and (Mwandawiro *et al.,* 2013). With frequent annual deworming of school going children and many health facilities in the county (Public 122, Faith Based 30 and private 64) (https://www.ehealth.go.ke) where untreated in deworming would seek treatment, there was need to assess the effectiveness of the deworming drugs. This study examined the study subjects before deworming and two weeks after deworming to establish the cure rate and egg reduction rate using albendazole.

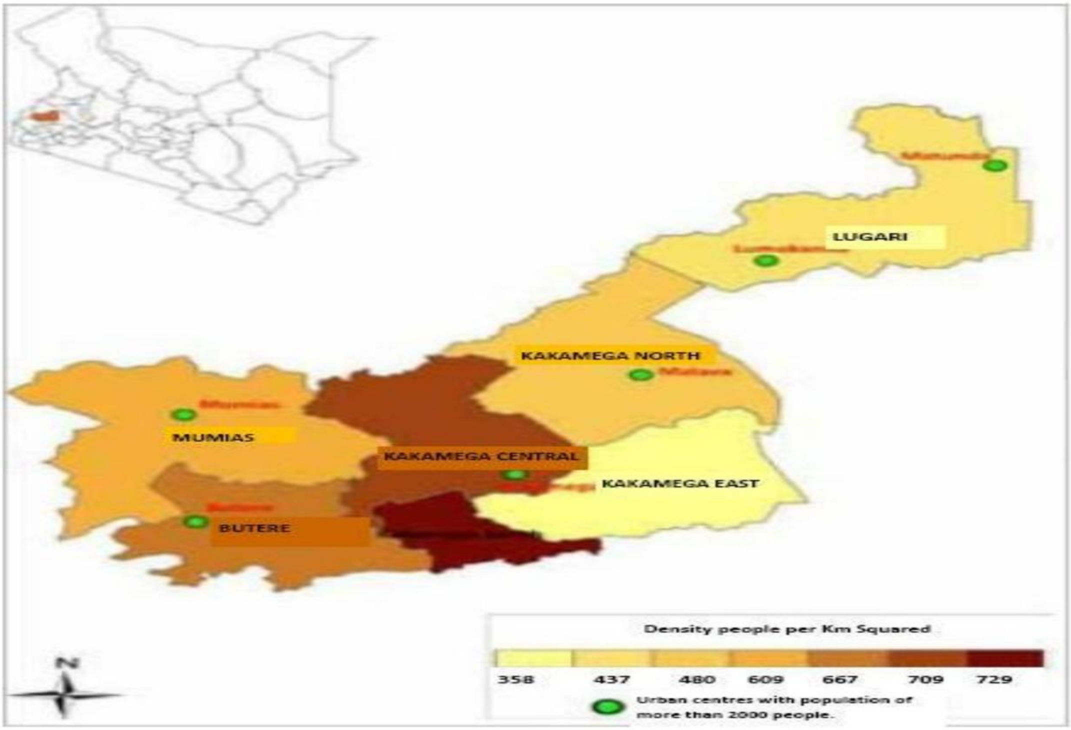

Fig 3.1 Map of Kakamega Districts before the review of current boundaries.

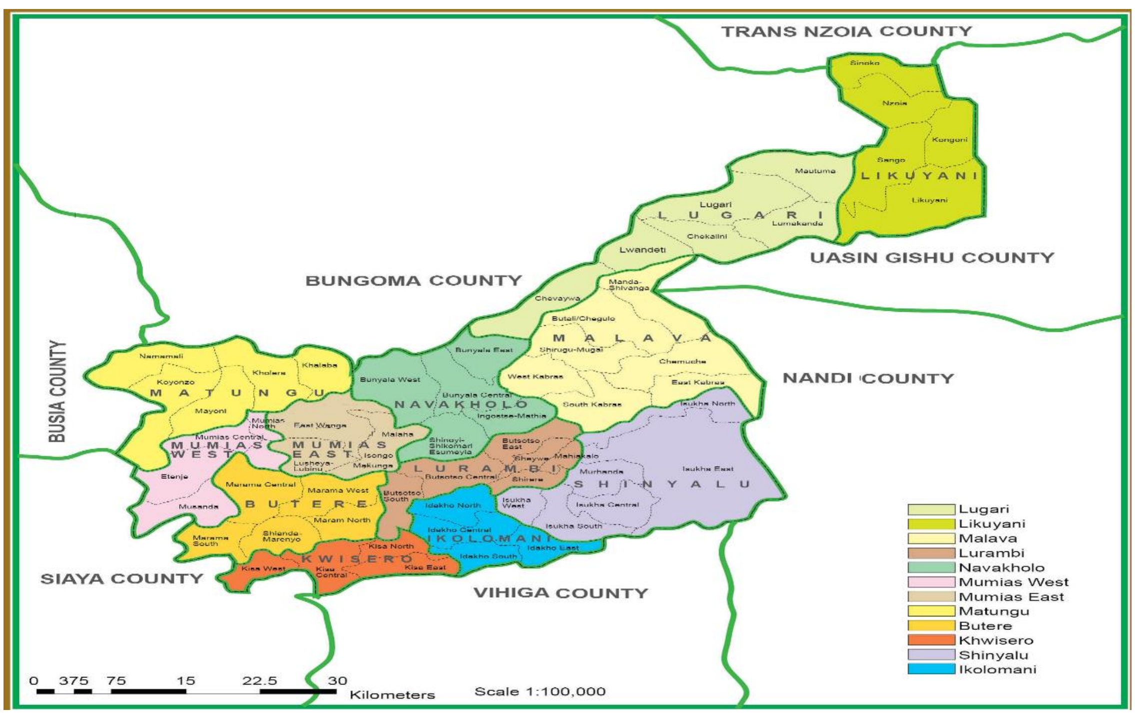

Fig 3.2 Map showing Study Sub Counties: Kakamega East (Shinyalu), Kakemega South (Ikolomani) and Kakamega Central (Lurambi).

3.4 Inclusion Criteria

School going children in sampled public primary schools whose parents or guardian consented and school children who assented were recruited in the study (Appendix 1 & Appendix 11).

3.4.1 Exclusion Criteria

School going children whose parents did not consent, and children who did not assent were excluded in the study.

3.5 Sample Size Determination

3.5.1 Sample Size Calculation for the school children

The sample size for the number of children per school was determined using Fishers *et al* (1998);

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

Baseline survey (27.2 %., County Health annual Report, 2013).

Z=1.96 p= 0. 272, q=1- 0. 272=0.728 e=0.05

$$n = \frac{(1.96)^2 \times 0.272\ (1-0.272)}{(0.09)^2}$$

n= 94 children per school

In each school, 94 pupils were recruited.

Z = is the sample for 5 % type

Where, n= is the sample required

Error for a normal distribution (Z=1.96)

P = is the baseline combined prevalence (Kakamega County annual health report), taken as 27.2% as indicated by M & E programme of NSBDP (Mwandawiro *et al*., 2013).

q= 1-p i.e. (1-0.272)

e = is the margin of error, set at 9%

The minimum sample size was 94 per school

Due to anticipated attrition, additional 10 % was added to the sample size to a total of 104 children per school.

i.e. (94 × 10/100) = 10 children added due to natural attrition

94 + 10= 104 children per school were recruited

Minimum sample size was 728 children study subjects in the baseline survey. A total of 731 children were sampled.

3.5.1.1 Sample size for Intervention

The school children in the baseline survey were followed up for post treatment survey. A total of 665 school children were sampled. The difference in the total number was due to absenteeism and probably transfers to other schools.

3.5.2 Sampling Procedure for study schools

Kakamega county had 1,086 primary schools with 862 puplic primary schools and 224 private primary schools respectively (Kakamega Basic Education Report, 2014). The school sampled were not part of M & E Programme (Mwandawiro *et al.,* 2013). In this study, all the listed public schools in the county Education office formed the sampling frame. Only Public primary schools in Kakamega County were legible for inclusion because they were more and had a high representation of wider population in the county. The sub counties were selected using lottery method (Mugenda *et al.,* 1999) where the then (Districts) were seven were serialized and put in container and three of them were randomly sampled. The district were later subdivided and renamed to form 12 sub counties. The number of public primary schools in Kakamega East (Shinyalu) were 96, Kakamega south (Ikolomani) 77 schools and Kakamega central (Lurambi) had 84 public schools (Kakamega county Education office, 2014) (Fig 1 & Fig 2).Seven schools were randomly sampled using lottery method (from county lists of schools in each sub county), using a random number generator in three randomly sampled sub counties of Kakamega East (Shinyalu) 3 schools, Central (Lurambi) 2 schools and South (Ikolomani) 2 schools . Mugenda *et al.*, 1999).

3.5.3 Sampling Procedure for school children

In each school, 18 children (9 girls and 9 boys) were randomly sampled per class using class registers as the sampling frame (Mugenda *et al.*, 1999). Children in ECD and those in classes 2-6 for a total of 108 children per school. Class registers were used to sample the children. Class one was not sampled because class one and ECD represent the same age group and there is a thin difference between the two. Some schools had low enrolment of ECD and therefore had put all pupils from ECD to class one together in one class.

Table 3.1 Summary of Sampled Schools and Children

	Schools in sub county sampled	**No. of schools Sampled**	**Number of pupils examined out of 108 randomly sampled**	
			Baseline (Pretreatment)	**Follow up survey (Pretreatment)**
Kakamega East	96	1. Shina	103	103
		2. Shamsinjili	107	93
		3. Iyenga	101	95
Kakamega Central	84	1. Matende	105	91
		2. Shitaho	107	95
Kakamega South	77	1. Bukhulanya	104	98
		2. Bukusi	104	90
Total	257	7	731	665

3.6 Data collection instrument

A demographic questionnaire was used to capture children information on demographics such as age, class and gender. (Appendix IV).

A structured observation checklist was used to collect data on WASH variables of interest which were aggregated at school-level (Appendix V). School WASH conditions included were the source of water, the availability of drinking water, and type of latrines. Pupils' per latrine ratio was also considered together with availability water and soap for hand-washing. Latrine cleanliness and structural condition were also assessed (Appendix V).

3.7 Pre-Testing.

The demographic data questionnaire and observation check list were pre-tested in a public primary school in Kakamega North (Malava) Sub County before use to ensure clarity and avoid ambiguity of the questions. There were adjustments made to ensure clarity in order to answer research questions and achieve study objectives.

3.8.1 Validity

Validity was achieved through field pre-testing of the observation checklist which adjusted in reference to the specific objectives for clarity and to answer the research questions. Examination of the stool specimen was done by qualified laboratory clinician with expertise in a well-established Division of vector borne diseases laboratory.

3.8.2 Reliability

Examination of stool samples was done using Double slides Kato Katz technique which has been recommended by WHO as method for detecting parasites ova in stool specimen (WHO, 2002). It is standardized protocol and it was used to quantify and concentrate helminth eggs (WHO, 2002). The questionnaire was pretested in another school prior to the study. For clarity, local language was used especially to the lower classes with the help of a class teacher.

3.9 Data Collection Technique

In this study, School observation checklist (Appendix V) was used to assess WASH through a real time, (observation made during school visit) inspection which was a more reliable method compared to subject reporting questionnaires (Gemiles, 2016). The pretreatment survey was conducted to provide the baseline data on the prevalence and intensity of subject's infections with Soil Transmitted Nematodes (STNs). Children were treated with a single dose of albendazole after the baseline survey in mass deworming programme. After deworming phase, post treatment survey was done after fourteen days. The study provided data based on parasitological examination of stool samples, observation checklist on school water, sanitation and hygiene and chemotherapeutic intervention using albendazole

Pretreatment prevalence and intensity was determined and later compared with post treatment results. The study analyzed the effectiveness of albendazole using prevalence reduction and egg reduction rate of STN infections. The level of prevalence reduction rate and egg reduction rate assessed the effectiveness of the drug in the seven public primary schools randomly selected in Kakamega County. The school WASH conditions were assessed and related to STN infections.

3.9.1 Baseline Data collection

3.9.1.1 Demographic data questionnaire

Data on demographic characteristics of recruited children was recorded as they submitted the stool sample (Appendix IV).
This ensured only those children who provided the stool sample recorded the demographic characteristics.

Class registers were used to record demographics characteristics of children in the lower classes at the time of study. All the data that was obtained was stored in a password protected personal number. The form was used in baseline and post treatment survey where children provided information on their age, gender and whether they were under any treatment or had been treated recently.

3.9.1.2 Laboratory Investigation

Quantitative data was obtained after screening children stool samples for Soil Transmitted Nematodes. Children were guided on how to collect fresh stool sample for Kato-Katz examination (Plate 3.1). Labelled poly pots were distributed to the recruited children to provide fresh stool specimen of their own. The samples of the children were coded with the child's unique identifier number written on the poly pot.

In brief, diagnosis was based on the number of soil transmitted Nematodes (STNs) eggs observed in examined quantities of stool using Kato Katz technique (WHO, 2002). Double Kato Katz slides were prepared from each stool sample. A quantity of 41.7mg of stool was sieved and fixed on a punched template. It was then mounted on slides and covered with malachite green impregnated cellophane. The slides were observed within one hour under the microscope at a magnification of X10. Samples were examined for the presence of, *Trichuris trichiura*, *Ascaris lumbricoides* and hookworm eggs and prevalence determined, both at baseline and follow up (Appendix VI).

Plate 3.1: Instruction to Pupils on Stool Collection.

3.9.1.3 Laboratory Results

Two slides (A & B) from each stool sample for each pupil were examined for STN and reported by two experienced laboratory technicians for confirmatory results. Findings were recorded in laboratory form for every pupil (form A for Slide A & Form B for slide B) (Appendix XII).

In accordance with the WHO guidelines, prevalence of infection was determined using (Montressor *et al.,* 1998) method. Individual infections with STN were classified into three classes based on mean infection intensity according to WHO classification (Table 3.2) (WHO, 2002). Random examination of 10% of the daily examined Kato- Katz slides was done for quality control by a different person. All recruited children sufficiently provided large stool sample to enable double Kato-Katz thick smears during baseline survey and in the follow-up survey.

To analyze the intensity of infection of STNs, the number of eggs observed for each species was recorded and converted into the number of eggs per gram of feces (EPG). This was calculated by multiplying the egg count by a conversion factor, which in this study was 24. Eggs that were seen per slide were therefore quantified by species and converted into eggs per one gram (EPG) of stool.

The total intensity from laboratory form A and B (Appendix XII) was averaged to give the data on intensity of infection for each pupil for every Soil Transmitted Nematode.The mean of Egg Per Gram for each child determined the infections as light, moderate or heavy infection as per WHO species-specific definitions (Table 3.1) WHO, 2002). The arithmetic mean egg intensity for each parasite was calculated using the formula by (Montresor *et al.*, 2002).

$$\text{Mean egg intensity} = \sum \frac{epg}{n}$$

epg is the sum of each individual epg and is divided by *n,* the number of children investigated.

Table 3.2 Classes of intensity (epg) of soil-transmitted Nematode infections

Soil Transmitted Nematodes	Light	Moderate	Heavy
A. lumbricoides	1–4,999 EPG	5,000–49,999 EPG	>49,999 EPG
Hookworms	1–1,999 EPG	2,000–3,999 EPG	>3,999 EPG
Trichuris trichiura	1–999 EPG	1000–9,999 EPG	>9,999 EPG

(WHO, 2002)

3.9.1.4 Data on observation checklist

Data from the observation check list on water, sanitation and hygiene factors was obtained through actual observations of toilet and hand washing facilities in every school. This information provided qualitative data on status of sanitation in the study schools.

3.9.2 Intervention

Parents meetings were held and sensitization messages were given in order to build awareness of the importance and benefits of child deworming. Drugs had been donated by GlaxoSmithKline to the schools through the county administration. With the help of class teachers who had been trained on drug administration, school children were instructed on how to swallow the drugs. This was strictly observed. Children were treated with albendazole (400 mg) with the help of trained health teachers under the supervision of local health personnel. A follow-up stool examination was collected within 14 days after treatment and examined using Kato-Katz following the same procedure as at baseline.

3.9.3 Data Collection in Post Treatment Survey

Demographic questionnaires were filled again in the post treatment survey. This was a measure to have the demographic information of children. Period for post-treatment examination for STN was two weeks as recommended by WHO, (2008). This was taken to be the best time without re-infection after treatment. It is the minimum manifestation time that ensures that all viable and dead eggs from helminth present at the time of treatment would have been expelled (WHO, 2008). Diagnosis was conducted using Kato Katz, prevalence and egg reduction rate were determined again as in baseline survey.

3.9.4 Cure rate

The cure rate was determined by comparing prevalence in baseline and follow up percentage of infected children. Data on cure rate was obtained after treatment. This was calculated as the percentage of infected individuals in a school who, after treatment, were no longer infected (usually determined on the basis of a negative stool specimen) (WHO, 2011).

$$\text{Cure rate} = 1 - \frac{(\text{number of subjects excreting eggs at follow-up})}{(\text{number of subjects excreting eggs at baseline})} \times 100$$

3.9.5 Egg Reduction Rate

Egg Reduction Rate (ERR) data on egg reduction was obtained from the observed intensity of STN excreted eggs in the infected pupils both in baseline and post treatment survey. This was determined per each STN observed. Egg reduction rate was calculated based on the WHO method (WHO, 2011).

$$\text{ERR} = 1 - \frac{(\text{mean feacal egg count (epg) post treatment})}{(\text{mean feacal egg count (epg) pre- treatment})} \times 100$$

3.9.6 Data Analysis

Prevalence of each type of soil transmitted nematodes was determined by WHO formula (WHO, 2011) and the Binomial logistic regression was applied to obtain 95% confidence intervals while taking into account clustering of schools. Arithmetic mean was used to express mean egg counts sincedistribution of egg counts was overdispersed. Negative binomial regression model was used to estimate 95% CIs taking into account clustering of schools. Intensity of infection were then classified into light, moderate and heavy infections. This was according to WHO guidelines (WHO, 2002). Prevalence of infections based on 95% Confident Intervals was calculated using binomial logistic regression.

Association between infection prevalence with either gender or age group was assessed using Chi square test. For purpose of this analysis and to ensure that there is enough observation per category, the following age groups were used: 4–5, 6–7, 8–9, 10–11, 12–>13 year-olds**.** Statistical significance was assessed using two samples independent t test. Significance for age group was assessed using ANOVA test.

The Egg Reduction Rate (ERR) in intensity of each species was determined by WHO formula (WHO, 2011). WASH factors were assessed through observation method. This was conducted in relation to school WaSH access and pre-treatment infection with STN infection. Presence of STN and intensity were the major outcomes involved of any STN species at pre-treatment level. Infection intensity was assessed using negative binomial regression. For the statistical analyses, STATA version 12.0 (STATA Corporation, College Station, TX, US) was used.

$$\text{Prevalence} = \frac{\text{Number of subjects testing positive}}{\text{Number of subjects investigated}} \times 100 \text{ (WHO, 2011)}$$

$$\text{ERR} = \frac{\text{mean epg before treatment - mean epg after treatment}}{\text{mean epg before treatment}} \times 100 \text{ (WHO, 2011)}$$

3.9.7: Ethical Considerations

The study was approved Kenyatta University Ethics and Research Committee (Appendix VIII). National Commission of Science and Technology gave the authority to conduct the study (Appendix VIII). After the field sample collection, all children were treated with albendazole (400 mg) which is the recommended dosage in prevalence above 20% in accordance with the National Deworming Guidelines (WHO, 2011). Anonymity of the study subjects was achieved and confidentiality observed. Parent consent was sought and obtained and children gave assent to participate.

CHAPTER FOUR: RESULTS

4.1 Demographic Characteristics of school children

In the baseline survey, the number of school children who provided stool samples and enrolled was 731 out of the 756 recruited. Out of the 731 children, there was equal representation for each gender with the males being three hundred and sixty six (367) which was (50.2%), while three hundred and sixty-four 364 (49.8%) were females. Mean age of the pupils was 10 years (SD = 2.6 years). This ranged between 4 years to 16 years of age (Fig. 4.1). Most of the pupils were between ages 10-14 years; 4years to 16years it is the range where STNs infections are at peak (WHO, 2012); and which they an respond to basic information in the survey questions (Sanchez *et al.*, 2013) (Fig 4.1).

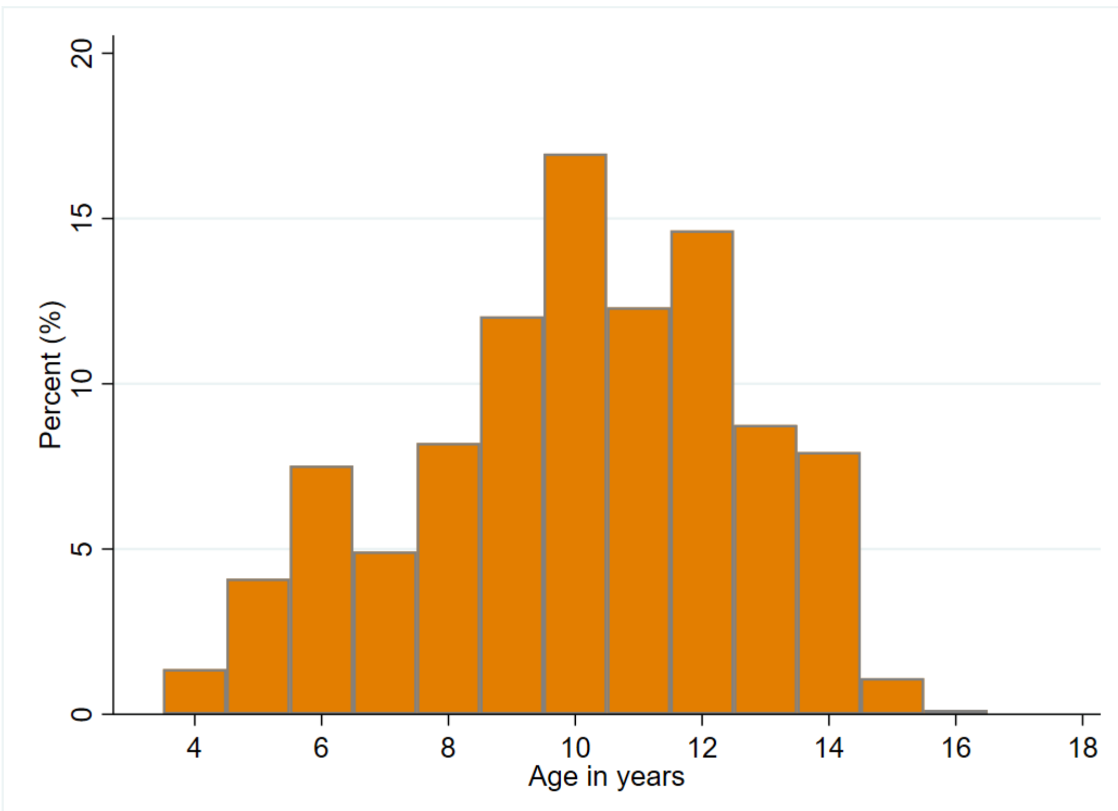

Figure 4.1.Distribution of Population bu Age

4.2 Distribution of the Study Population by Sub County

The study was conducted among 731 children in baseline (pretreatment) in 7 primary schools within three Sub-counties in Kakamega County. Out of 731 children, two hundred and eight (28.5%) were from Kakamega South (Ikolomani), 311 (42.6 %) pupils were from Kakamega East (Shinyalu), while 212 (28.9%) pupils were from sub-county of Kakamega Central (Lurambi) (Table 4.1). Sampled schools in the sub counties were Bukhulanya and Bukusi in Kakamega South (Ikolomani); Shina, Shamsijili, and Iyenga in Kakamega East (Shinyalu), while Matende and Shitaho were from Kakamega Central (Lurambi). A total of 665 participants formed the post treatment survey. The discrepancy of 66 pupils between the baseline and follow up survey may have been due to the duration between the two surveys due to teachers strike threats 2014 (www. Standardmedia.co.ke). The strike took place in second term (May to July, 2014) making the deworming exercise to be done in third term. Out the 665 children, One hundred and eighty eight, 188 (28.3%) were from Kakamega South, 291 (43.7 %) children were from Kakamega East, while 186 (28%) pupils were from Kakamega Central sub-county (Table 4.1). Out 731 children who participated in the baseline survey, 66 of them were not not in school follow up survey.

Table 4.1 Children and Schools Surveyed in each Sub-County: Pre and Post Treatment

Sub County			Pre-treatment	Post-treatment
	Schools in subcounty	**Sampled schools**	**Baseline Children %**	**Follow up Survey Children %**
Kakamega South	77	2	208 (28.5)	188(28.3)
Kakamega East	96	3	311 (42.6)	291(43.7)
K. Central	84	2	212 (28.9)	186 (28)
TOTAL	**257**	**7**	**731 (100)**	**665 (100)**

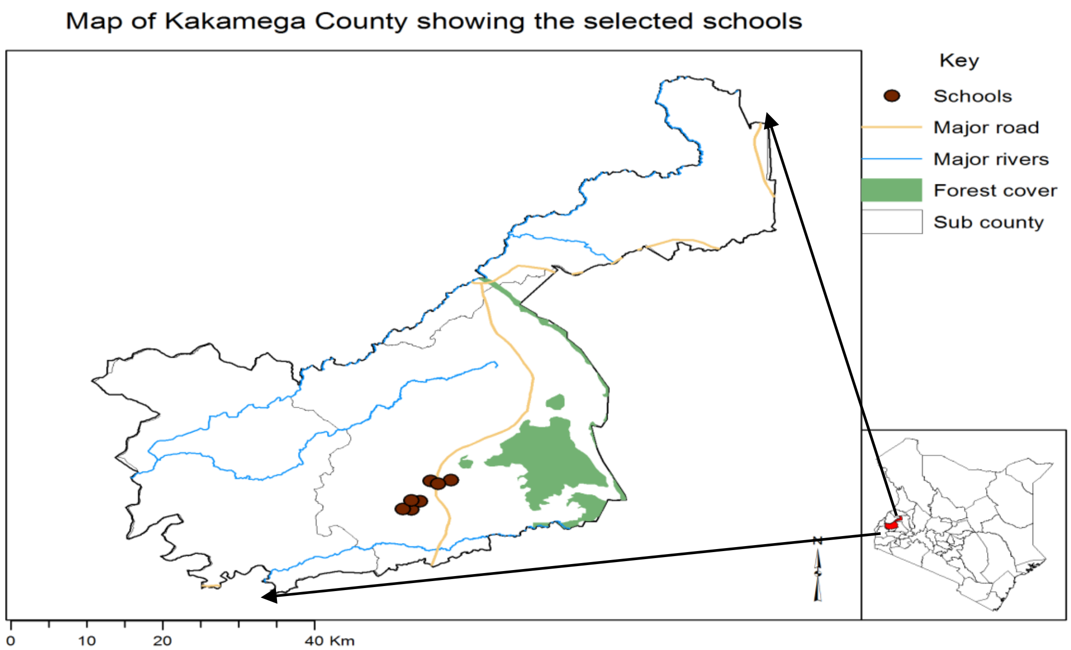

Figure 4.2: Map of Kakamega County of Kakamega county showing study schools (Source: CRA, 2013) *https://www.researchgate.net*)

4.3 School Water, Sanitation and Health covariates

Of the seven schools sampled in this study, three schools (42.9%) had treated tap water source. These were Matende and Shitaho (Kakamega Central) and Bukhulanya (Kakamega South). Three schools, Bukusi (Kakamega South), Shina, Shamsinjili and Iyenga (Kakamega East) untreated water source. They sourced water from springs and rivers close to the schools.

All schools had ordinary pit latrine (100%) and five (71.4%) had hand-wash facilities with water and soap available. Drinking water was available in Bukusi and Bukhulanya (Kakamega South), Matende and Shitaho in Kakamega central. The other schools, Shina, Shamsinjili and Iyenga (Kakamega East) did not have water at the time of the baseline survey. Of the seven study schools, four had their latrines clean at the time of observation during the baseline survey; These included Shamsinjili (Kakamega East), Matende in Kakamega central) and Bukhulanya and Bukusi (Kakamega South). All the seven schools (85.7%) except one had latrines in good structural condition. The ratio of pupil per latrine was 36:1 slightly above the standard of 30 pupils for every latrine as recorded Kenya Government (G o K, 2008.Table 4.2a and b).

Table 4.2a School WaSH Characteristics classification subcounty and by School.

School WaSH conditions	**Kakamega East**			**Kakamega C**		**Kakamega S**	
Schools	**Shamsinjili**	**Shina**	**Iyenga**	**Matende**	**Shitaho**	**Bukhu**	**Bukusi**
Water source: Imroved (1) vs Unimproved(0)	0	0	0	1	1	1	0
Pupils per latrine: <30ppl (1) vs ≥30ppl(2)	1	2	1	1	1	1	2
Handwashing facility with water available (1) vs Not available(0)	1	1	0	1	1	1	0
Drinking water: Available (1) vs Not available (0)	1	0	0	1	1	1	1
Latrine sanitation: clean (1)/Not clean (0)	1	0	0	1	0	1	1
Latrine structural Conditions. Good(1):Yes; Poor (0) No	1	1	1	1	0	1	1

Key: (1) Improved; Ratio of latrines <30pple; Available hand wash; Available drinking water; Clean latrine; Good latrine condition, Pupils per Latrine:<30 pupil (1) vs ≥30pupil(2)

Improved water source: Access to pipe water into dwelling from piped water into yard, public tap, bore holes protected wells and springs and bottled water (Improved sources are defined by the UNICEF/WHO joint monitoring programme (wash ssinfo.org)

Improved water source: Water collected from unimproved sources, unprotected spring , wells and surface water.

(0) Unimproved ; Ratio of latrines ≥30pple;Not available hand wash; Not available drinking water; Unclean latrine ; Poor latrine condition

Table 4.2(b) School WaSH Characteristics classification by Sub county

School Characteristics	Overall (n=7) N (%) or mean(SD)	Kakamega East (n=3) N(%) or mean(SD)	Kakamega Central (n=2) N(%) or mean(SD)	Kakamega South (n=2)N(%) or mean(SD)
Number of children in school	731	311	212	208
Improved water source	3 (42.9%)	0	2 (100%)	1 (50.0%)
Ordinary pit latrine	7 (100%)	3 (100%)	2 (100%)	2 (100%)
Pupils per latrine	36.5 (10.5)	32.1 (14.6)	37.3 (0.4)	42.5 (10.4)
Hand-wash facility with soap and water: Available	5 (71.4%)	1 (33.3%)	2 (100%)	2 (100%)
Drinking water: Available	5 (71.4%)	1 (33.3%)	2 (100%)	2 (100%)
Number of months without drinking water	3.1 (1.7)	2.7 (2.3)	4 (1.4)	3 (1.4)
Latrine sanitation: clean	4 (57.1%)	1 (33.3%)	1 (50.0%)	2 (100%)
Latrine structural integrity: good condition	6 (85.7%)	3 (100%)	1 (50%)	1 (50.0%)

Plate 4.1 Main Source of Drinking Water (improved water source) in Matende primary school

Plate 4.2: Handwashing Facility in Shamsinjili primary school

4.3.1 Associations between School WaSH Conditions and STN Infection

Tests on most variables did not reveal any significant associations between helminth prevalence and infection intensity. Treated water was not significantly associated with both lower infection prevalence (χ^2 = 0.875, df = 1, p=0.350) and intensity (χ^2 = 0.1944, df = 1, p=0.659). A fully equipped hand-wash facility with water and soap was not associated with both lower infection prevalence (χ^2 =0.4667, p=0.495) and intensity (χ^2 =0.0583, df = 1, p=0.809) while availability of drinking water had no significant association with lower infection intensity and prevalence (χ^2 =0.0583, df = 1, p=0.809) (Table 4.3). There was no association between latrine sanitation and infection prevalence (χ^2 =1.5556, df = 1, p=0.212) and latrine sanitation with infection intensity (χ^2 =0.1944, df = 1, p=0.695). Latrine structural condition was not significantly associated with infection prevalence (χ^2 =0.1944, df = 1, p=0.695) and infection intensity (χ^2 =1.5556, df = 1, p=0.212) (Table 4.3). The ratio pupils per latrine was significantly associated with infection intensity (χ^2 =3.7333, df = 1, p=0.047) (Table 4.3).

Table 4.3 Associations between School WaSH Conditions and Any STN Infection (n=7)

School WASH conditions	Infection Prevalence		Infection Intensity	
	Pearson Chi-square	**p-value**	**Pearson Chi-square**	**p-value**
Water source: Improved vs Unimproved	0.8750	0.350	0.1944	0.659
Pupils per latrine: <30ppl vs ≥30ppl	0.4667	0.495	3.7333	0.047
Hand washing facility,water soap Available vs. Not available	0.4667	0.495	0.0583	0.809
Drinking water: Available vs. Not available	2.9167	0.088	0.0583	0.809
Latrine sanitation: Clean vs. Not clean	1.5556	0.212	0.1944	0.659
Latrine structural condition: Good condition vs Poor condition	0.1944	0.659	1.5556	0.212

4.4. Pre-treatment Prevalence of Soil Transmitted Nematodes

Pre-treatment survey indicated that out of 731children, 322 were infected with combined STNs 44.05%, 95% CI (35.80-54.20). The most prevalent STN species was *Ascaris lumbricoides* 43.5%, 95% CI (35.21-53.74) with 318 infected. The above soil transmitted nematodes infections were all significant, (P=0.000) (Fig 4.3).

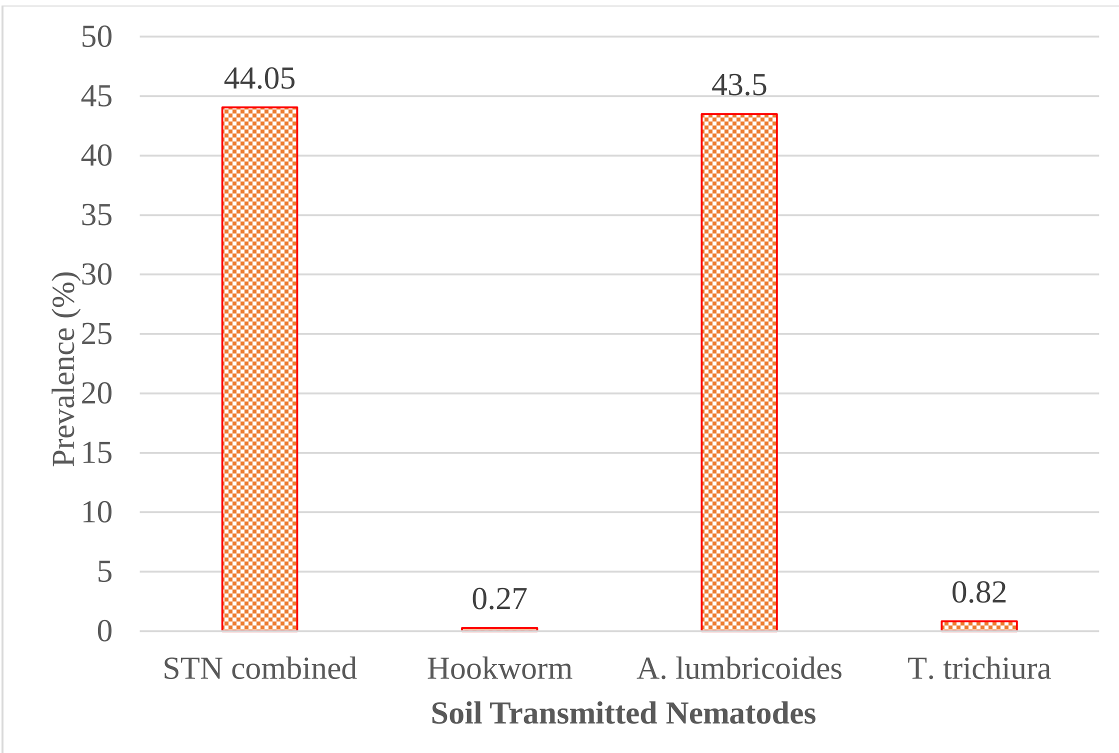

Figure 4.3 Pre-treatment Prevalence of Soil Transmitted Nematodes

4.5 Pre-treatment Intensity of Soil Transmitted Nematodes

The overall intensity of the combined STN species was 3674 epg, 95% CI (2560-5274*).* *Ascaris lumbricoides* had the highest intensity of 3673 epg, 95% CI (2559-5274), Hookworm (*Ancylostoma duodenale* and *Necator americanus*) were not separately identified in this study because of their indistinguishable eggs by microscopy (WHO, 2011).

Table 4.4 Pre-treatment intensity of STNs infections

Infection	Mean Intensity (epg)	95%CI
STN combined	3674	(2560-5274)
Hookworm	0.33	(0.05-2.29)
A. lumbricoides	3673	(2559-5274)
T. trichiura	0.84	(0.16-4.38)

4.6 Prevalence of Soil Transmitted Nematodes (STNs) in each school

Among the 7 schools surveyed, there was higher prevalence of STN combined among children who were able to provide stool specimen. In Shitaho primary school out of, 62.6% (95% CI 54.1-72.5). Bukusi primary school had a prevalence of 55.6% (95% CI 46.6-66.3) while Iyenga primary had the least prevalence of 26.7% (95% CI 19.4-36.9). Hookworm was only observed in Bukhulanya primary school with a low prevalence of 1.8% (95% CI 0.5-7.2) (Figure 4.4). Shitaho had the highest prevalence of *Ascaris lumbricoide* 62.6% (95% CI 54.1-72.5). Iyenga primary had the lowest prevalence of Ascaris 26.7(19.4-36.9) (Table 4.5). Prevalence of *Trichuris trichiura* was only observed in four schools namely Bukhulanya, Matende, Bukusi, and Shina. Shitaho, Shamsinjili and Iyenga primary schools did not record *Trichuris trichiura* infection (Figure 4.4).

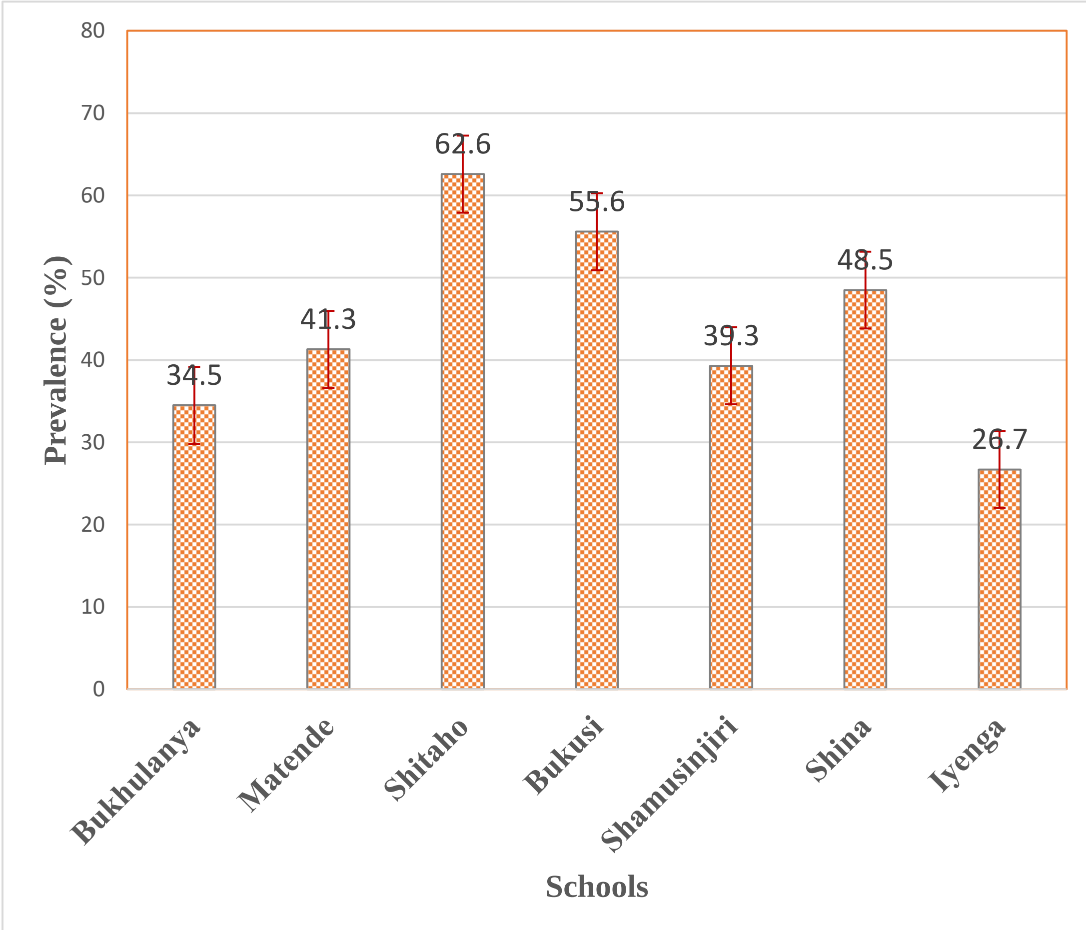

Figure 4.4 Prevalence of Soil Transmitted Nematodes (STNs) by school

4.6.1 Intensity of Soil Transmitted Nematodes (STNs) by School

Mean intensity for STNs species was done based on age, gender, schools, and Sub County. These means are estimates as opposed to actual counts, hence the numbers are rounded off to the nearest whole numbers. Among the 7 schools surveyed, there was high mean intensity of STN combined in Iyenga and Shitaho primary schools with 11772 (6889-20115) and 11667 epg (95% CI 8400-16205) (Table 4.5) respectively. Shina primary had the least STN combined mean intensity of 5584 epg (3820-8161). Hookworm was only observed in Bukhulanya primary school with a mean intensity of 120 epg (95% CI 41-355) and mean intensity (Table 4.5). Iyenga primary school had the highest mean intensity of *Ascaris lumbricoides* 11772 (6889-20115) epg followed by Shitaho 11667 (8400-16205) and Matende 9367 epg (6002-14621) respectively (Table 4.5).

Table 4.5 Intensity of Soil Transmitted Nematodes (STNs) by School

School	STN combined Mean Intensity	Hookworm Mean Intensity	*A. lumbricoides* Mean Intensity	*T. trichiura* Mean Intensity
Bukhulanya	6538(4115-10387) *	120(41-355)*	6893(4364-10888) *	24(18-32)*
Matende	9367(6002-14621) *	0	9355(5937-14740) *	264(39-1804) *
Shitaho	11667(8400-16205) *	0	11667(8400-16205) *	0
Bukusi	7368(4827-11246) *	0	7504(4927-11427) *	0
Shamusinjiri	5973(3881-9194) *	0	5973(3881-9194) *	0
Shina	5584(3820-8161) *	0	5697(3929-8262) *	0
Iyenga	11772(6889-20115) *	0	11772(6889-20115) *	0

* Indicates values with statistical significance $p < 0.05$: The values are mean estimates, rounded off to the nearest whole number

4.7.1 Distribution of Prevalence of Soil Transmitted Nematodes (STNs) by gender

The prevalence of STN combined infection and any single STN did not vary markedly between male and female participants ($\chi^2 = 0.0026$, df = 1, p=0.960) (Figure 4.5)

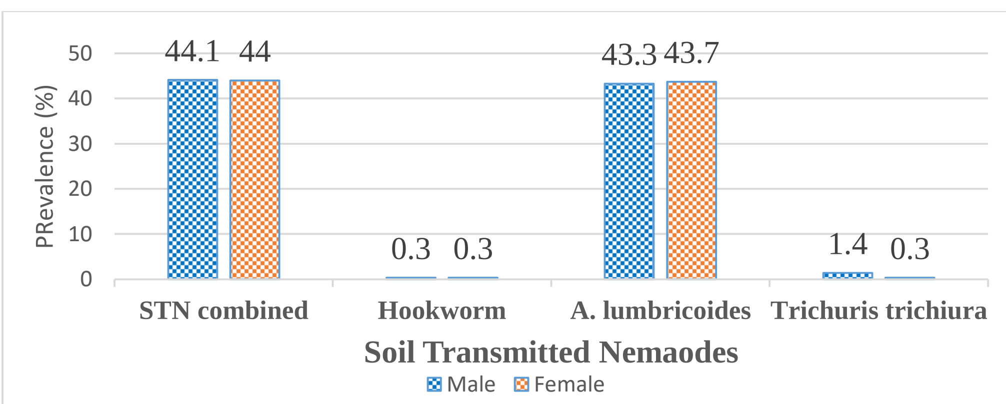

Fig 4.5 Prevalence of Soil Transmitted Nematodes (STNs) by Gender

4.7.2 Distribution of intensity of Soil Transmitted Nematodes (STNs) by gender

Except for the intensity of *Trichuris trichiura*, females recorded higher intensity, though not significant, than males for the rest of STNs identified (t=1.0889, p=0.277) (Table 4.6).

Table 4.6. Intensity of Soil Transmitted Nematodes (STNs) per Gender

Gender	STN combined Intensity	Hookworm Mean Intensity	*A. lumbricoides* Mean Intensity	*T. trichiura* Mean Intensity
Male	7150 (5474-9339)	0.10 (0.01-0.66)	7281 (5647-9386)	118 (32-432)
Female	9549 (7250-12577)	0.56 (0.08-4.06)	9607 (7312-12624)	0.07 (0.01-0.48)

4.8. Prevalence (%) of Soil Transmitted Nematodes species by Age

Children between 4 – 5 years showed higher prevalence, 67.5% (95% CI 55.5-82.1), for STNs combined though marginally not significant (χ^2 =10.715, df = 1, p=0.057) (Figure 4.6).

4.8.1 Prevalence (%) of *Ascaris lumbricoides* by Age

The Prevalence of *Ascaris lumbricoides* was significantly highest (67.5%) among pupils in the age category of 4-5 years. The other age categories had prevalence ranging between 40% and 45% (χ^2 = 11.0636, p=0.049) (Figure 4.6)

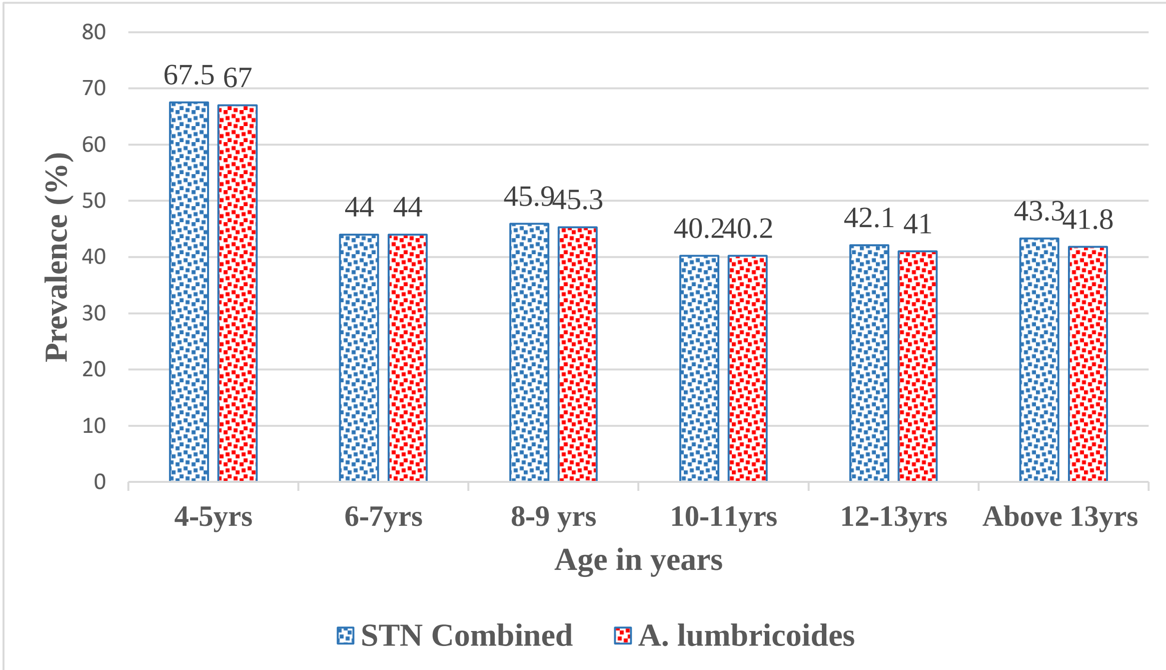

Figure 4.6 Prevalence of Soil Transmitted Nematodes by age

4.8.2. Prevalence (%) of *Trichuris trichiura* by Age

There was significantly low prevalence levels of *Trichuris trichiura* in age groups (8-9), (12-13) and (>13) while the remaining age groups had no *Trichuris trichiura* infection (χ^2 =14.4899, p= 0.013) (Figure 4.7).

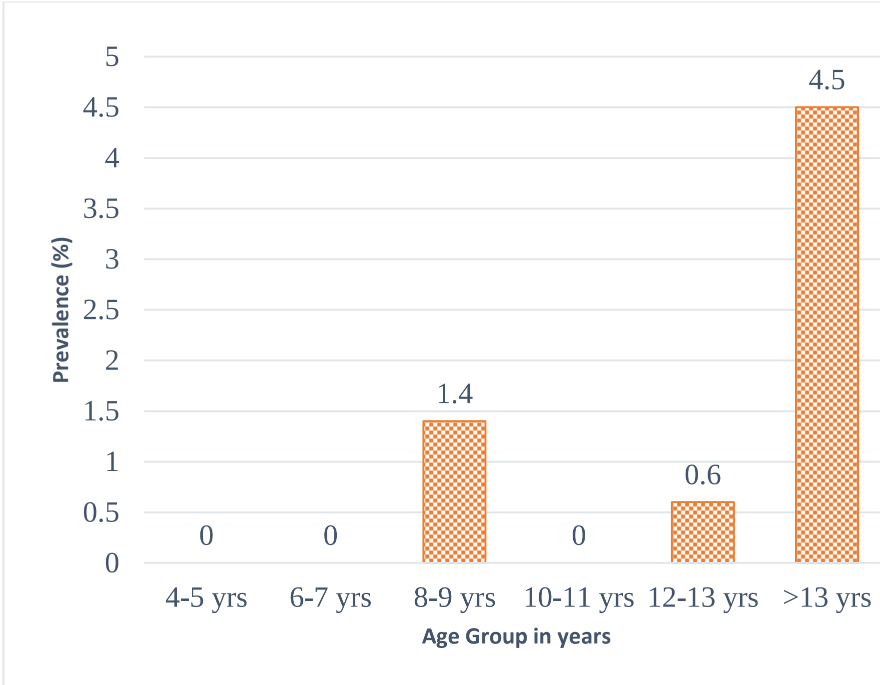

Figure 4.7 Prevalence *(%) of Trichuris trichiura* by Age

4.9 Intensity of Soil Transmitted Nematodes

4.9.1 Intensity of Soil Transmitted Nematodes by Age

The intensity of STN combined was highest though not significant in the age groups (6-7) years followed by (12-13) years; 10,752 epg and 9,217 epg respectively (F=3.54, df = 5, P=0.0603 (Figure 4.8).

4.9.2 Intensity of *Ascaris lumbricoides* by Age

There were higher levels of *Ascaris lumbricoides* intensity in age groups (6-7) and (12-13) years. This was not significant. Children above 13 years had the least mean intensity of *Ascaris lumbricoides,* 4,241 epg (F=3.55, df = 1, P=0.0601) (Figure 4.8).

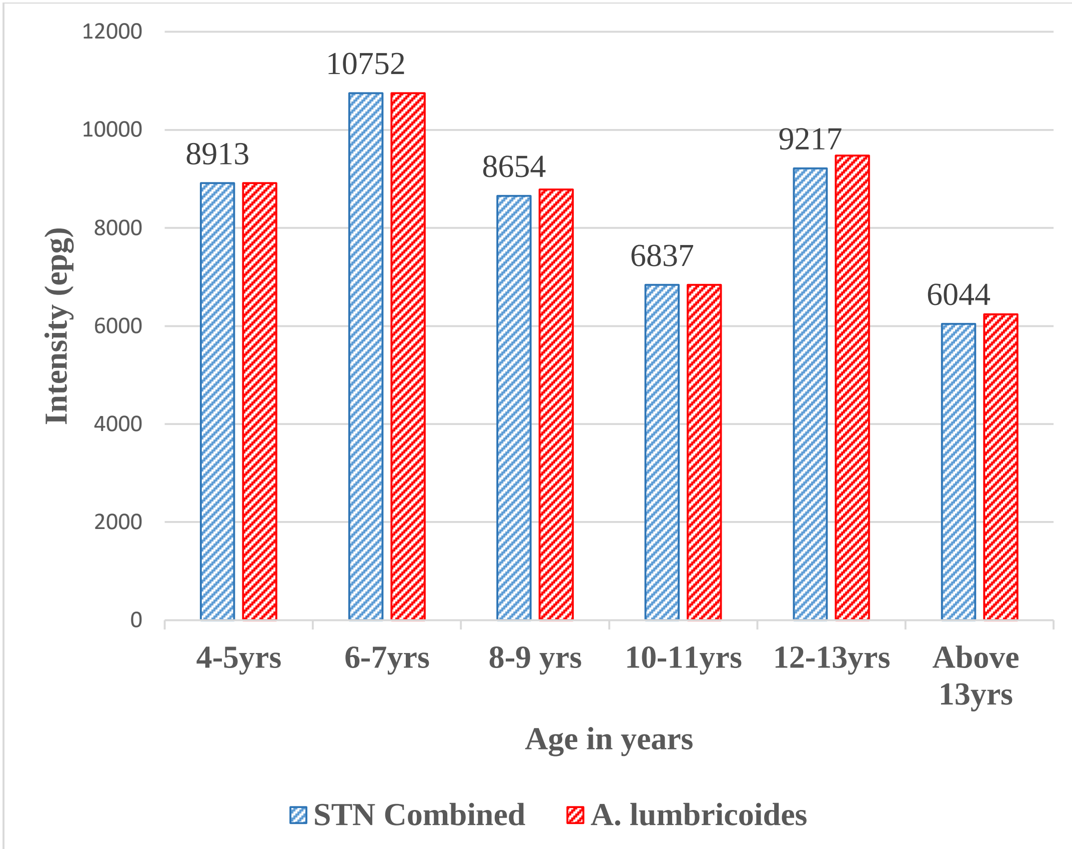

Figure 4.8 Intensity of Soil Transmitted Nematodes by Age

4.9.3 Intensity (%) of *Trichuris trichiura* by Age

There were low levels of intensity of *Trichuris trichiura* infection that were only present in age groups (8-9) and >13 years (F=1.18, df = 1, P=0.2785) (Figure 4.9).

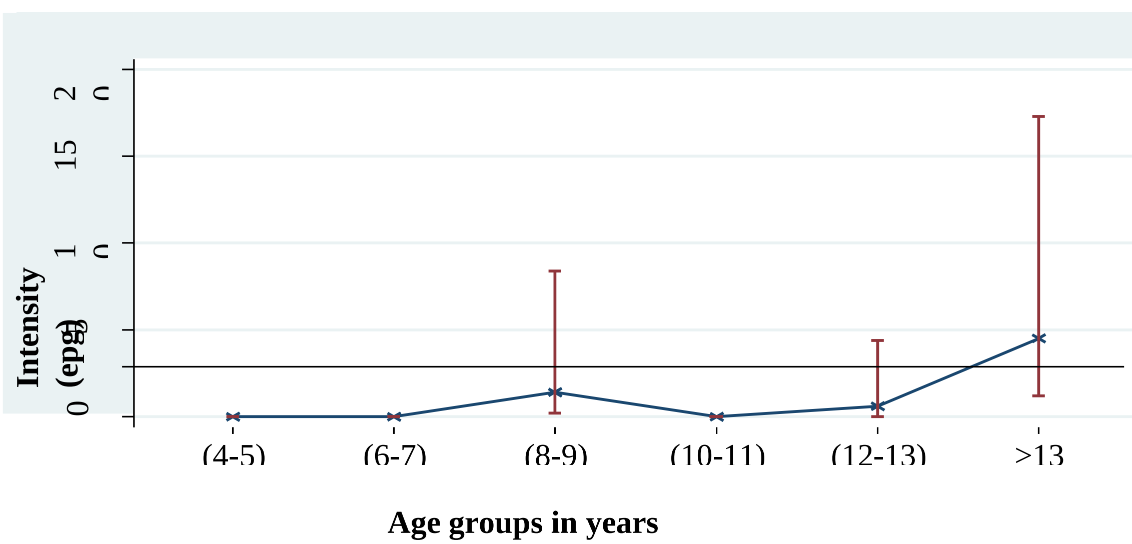

Figure 4.9 Intensity (%) of *Trichuris trichiura* by Age

4.10 Pre-treatment Prevalence and Mean Intensity of Soil Transmitted Nematodes

Post-treatment survey indicated that out of 665 children, 15 were still infected with combined STNs 2.3 %, 95% CI (1.3 -3.8). The most prevalent STN species was *Ascaris lumbricoides* 2.3%, 95% CI (1.3 -3.8) with 15 infected. The above soil transmitted nematodes were all significant, (P=0.000) (Table 4.7). The overall post treatment intensity of the combined STN species was 59 epg, 95% CI (31-111*). Ascaris lumbricoides* had the highest intensity of 59 epg, 95% CI (31-110), hookworm prevalence was however low 0.27%, 95% CI (0.06-1.09) *Trichuris trichiura* had generally low prevalence, and 0.82, 95%CI (0.38-1.78) respectively (Table 4.7).

Table 4.7 Post treatment Prevalence and Intensity of Soil Transmitted Nematodes

Infection	**Post-treatment Cases**	**Post-treatment Prevalence (%)**	**[95% CI]**
STH combined	15	2.3	[1.3-3.8]
Hookworm	2	0.3	[0.1-1.1]
A. lumbricoides	15	2.3	[1.3-3.8]
T. trichiura	6	0	[0-0]
Post treatment		**Mean epg**	**[95%CI]**
STH combined		59	[31-111]
Hookworm		0.32	[0-1]
A. *lumbricoides*		59	[31-110]
T. trichiura		0	[0-0]

4.10.1 Comparisons of Prevalence and Intensity between pre to post treatment

4.10.1 Overall Prevalence in Pre and Post Treatment of STNs

The prevalence reduction for STN combined, *Ascaris lumbricoides* and *Trichuris trichiura* was highly significant, 94.9 %, 94.4%, 100% respectively (p=0.001). Hookworm non- significantly increased (p=9.44) (Figure 4.10).

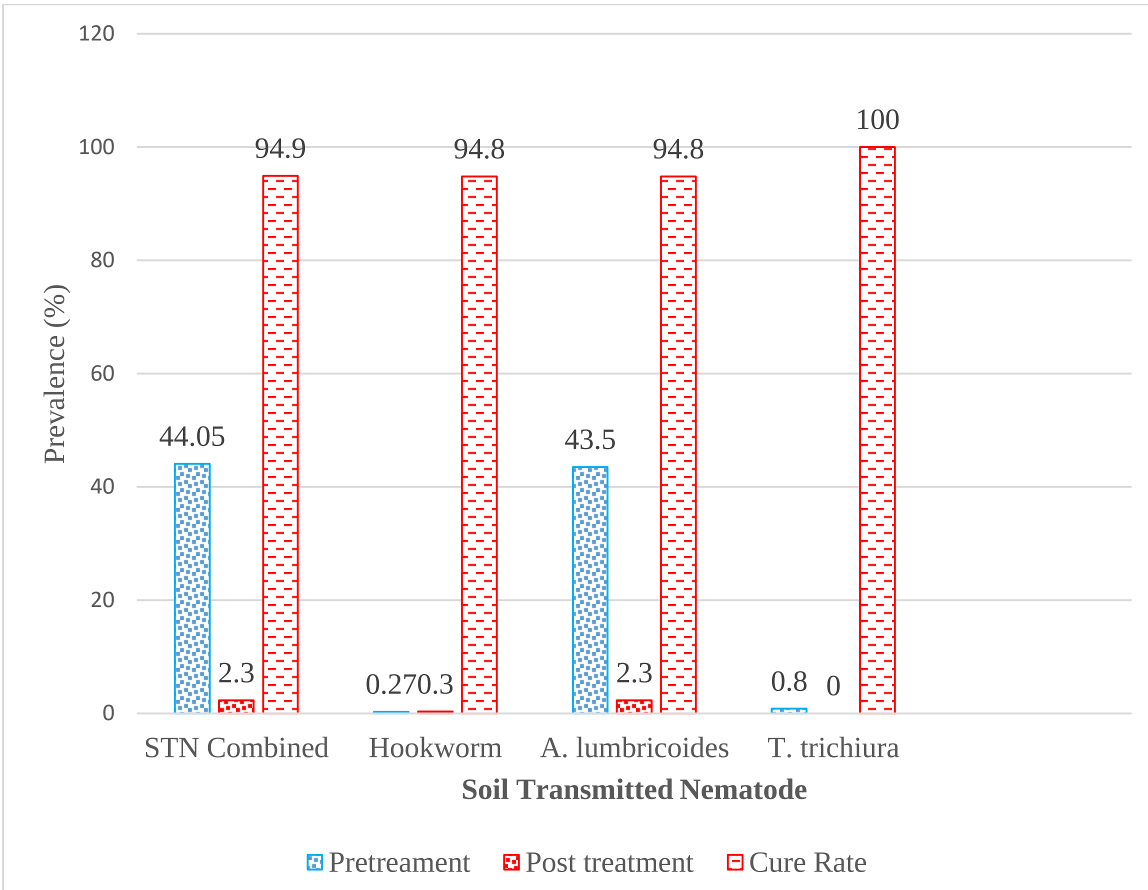

Figure 4.10 Prevalence of STN in Pre and post treatment survey

4.10.2 Intensity of STNs Pre and Post Treatment Survey

The STN combined intensity of infection at Pre-Treatment was 3673 epg (95% CI: 2559 - 5274) for *Ascaris lumbricoides*, 0 epg (95% CI: 0 - 2) for hookworm, and 1 epg (95% CI: 0 - 4) for *Trichuris trichiura*. The combined STN intensity was 3674 epg (95% CI: 2560 - 5274). At Post-Treatment, the intensity of infection significantly reduced to 59 epg 95% CI: 31 - 110), ERR 98.4%, (p=0.001) for *Ascaris lumbricoides*, while hookworm had 1.2 % ((p=0.944) ERR and *Trichuris trichiura* intensity of infection reduced to significantly to 0 epg, ERR 100%,(p=0.001) (Table 4.7).

Table 4.8 Intensity of STNs and the Egg Reduction Rate in (%)

	Pre-Treatment Intensity(epg) [95%CI]	**Post-Treatment Intensity(epg) [95%CI]**	**ERR (epg) [p-value]**
STN combined	3674 [2560-5274]	59 [31-111]	98.4% [p=0.001]
Hookworm	0.33 [0.05-2.29]	0.32 [0.09-1.16]	1.2% [p=0.993]
A. lumbricoides	3673 [2559-5274]	59 [31-110]	98.4 [p=0.001]
T. trichiura	1 [0-4]	0 [0-0]	100% [p=0.001]

4.10.3 Distribution of Prevalence (%) of STN for Pre & Post Treatment by School

Shitaho primay school had the highest number of cases detected while Iyenga primary had the least (Table 4.8).There was significant difference in STN infection across schools (χ^2 = 29.439, df = 6, p<0.05) (Table 4.8).

Table 4.9 Distribution of Prevalence (%) of STN for Pre & Post Treatment by School

Schools	**Pre-treatment Infections**			**Post-treatment Infections**		
	Cases	No. pupils Examined	Prevalence (%) C. I	Cases	No. pupils Examined	Prevalence (%) C. I
Bukhulanya	38	108	35(26.7-44.7)	1	98	1(0.1-7.1)
Matende	43	105	41(32.9-52.0)	2	91	2.2(0.6-8.7)
Shitaho	67	107	62.6(54.1-72.5)	3	95	3.2(1.0-9.6)
Bukusi	55	100	55(46.6-66.3)	1	90	`1.1(0.2-7.8)
Shamsinjili	42	107	39(31.0-49.7)	5	93	5.4(2.3-12.6)
Shina	50	103	48.5(39.8-59.2)	2	103	1.9(0.5-7.7)
Iyenga	27	101	26.7(19.4-36.9)	1	95	1.1(0.1-7.4)
	322	731		15	665	

4.10.3.1 Cure rate of Soil Transmitted Nematodes by School

At Pre-Treatment, all schools had high prevalence of above 30% except Iyenga primary school which had below 30% (Fig 4.10). All schools had significantly high cure rate of STN combined p<0.001, (Fig 4.10).

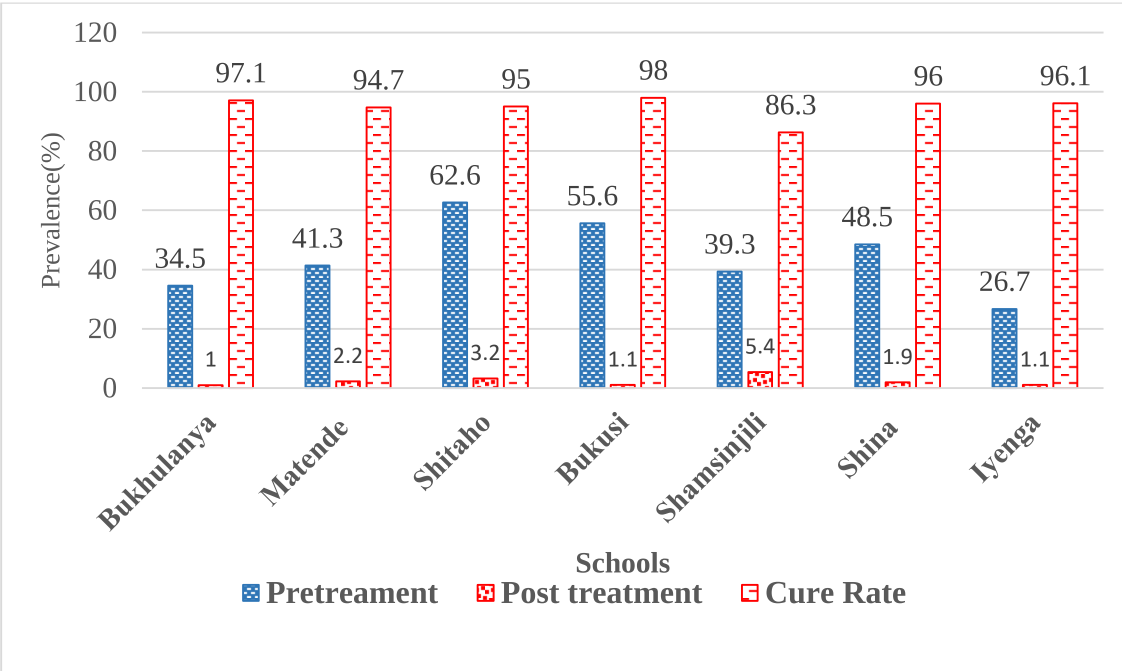

Figure 4.10 Prevalence of STN (%) for Pre & Post Treatment by School

4.10.4. Intensity of STN for Pre & Post Treatment by School

There was significant high reduction on mean intensity of STN combined in all the seven schools p<0.001 (Fig 4.11). Three of the schools, Bukhulanya, Bukusi and Iyenga had zero mean intensity of STN combined post treatment (Fig 4.11). In all the schools, there was significant high egg reduction rate (p=0.001) (Figure 4.11).

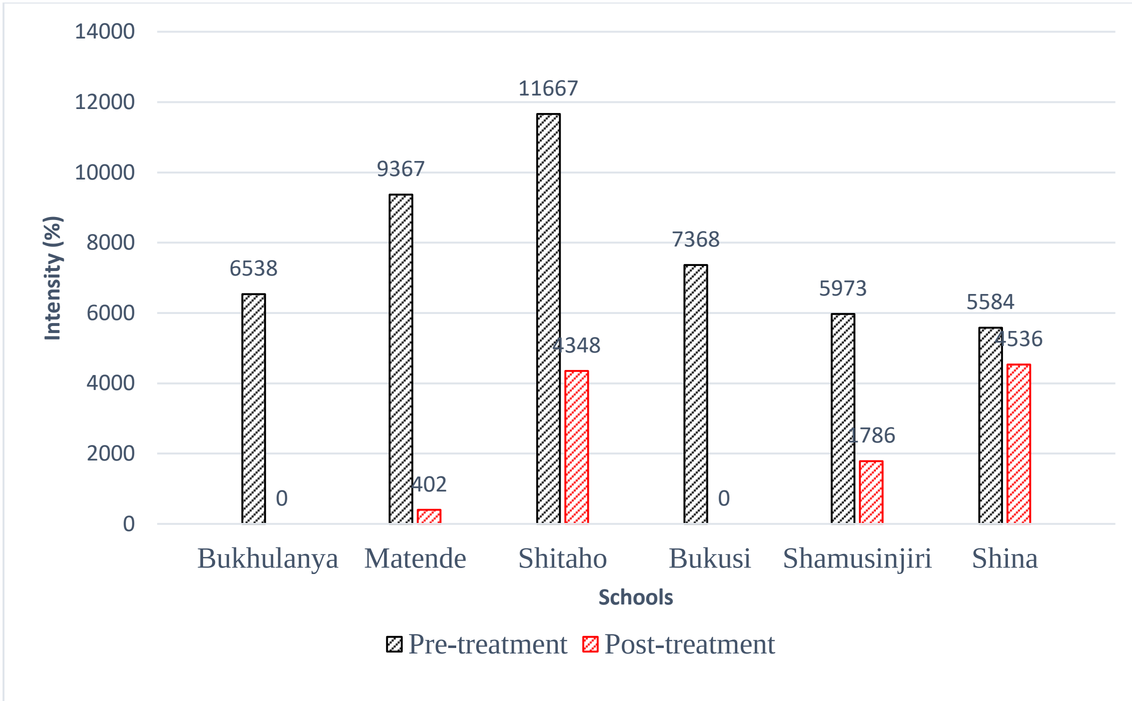

Figure 4.11 Intensity of STN for Pre & Post Treatment by School

4.10.5 Prevalence (%) of STN for Pre & Post Treatment per Sub-County

All the three sub counties had a highly significant cure rate of STN Combined between Pre & Post Treatment; $p<0.001$, (Figure 4. 12). There was also significant difference in STN infection by sub county ($\chi^2 = 8.098$, df = 2, $p<0.017$)

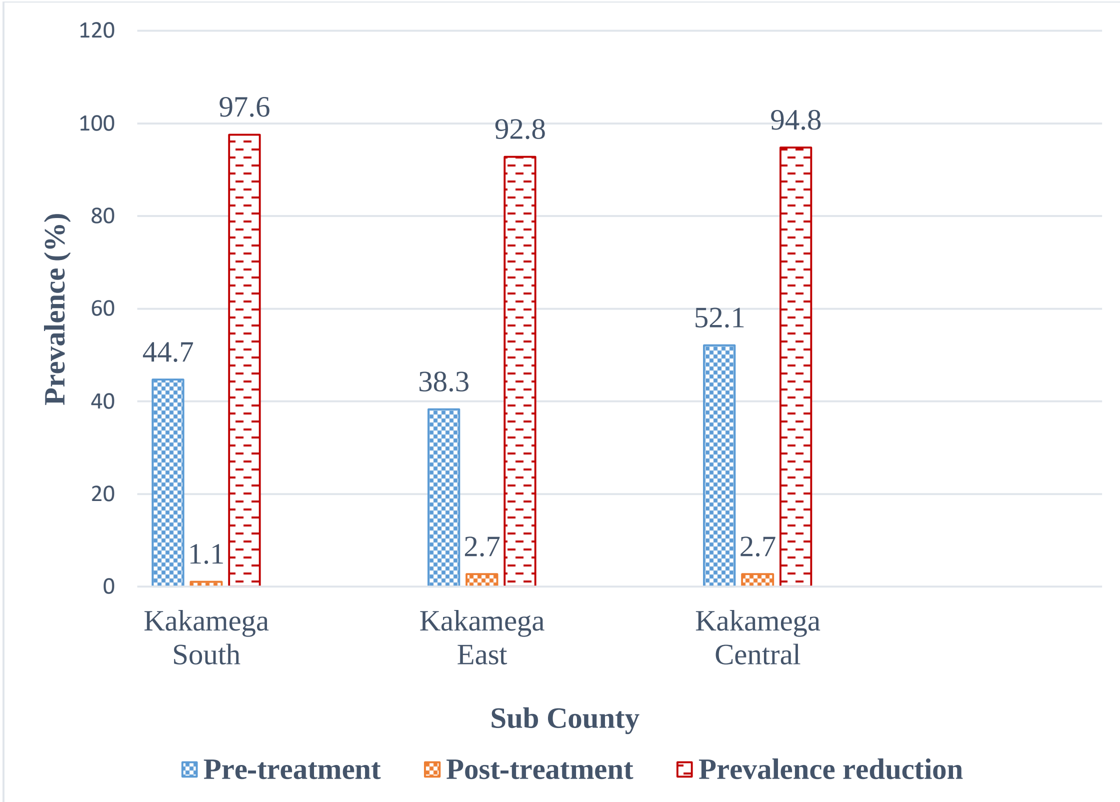

Figure 4.12 Prevalence (%) of STN for Pre and Post Treatment per Sub-County

4.10.6 Intensity of STN for Pre and Post Treatment by Sub-County

Reduction of intensity of STN combined was highly significant in the three sub counties between pre-treatment and post treatment p<0.001, (Figure 4.13).

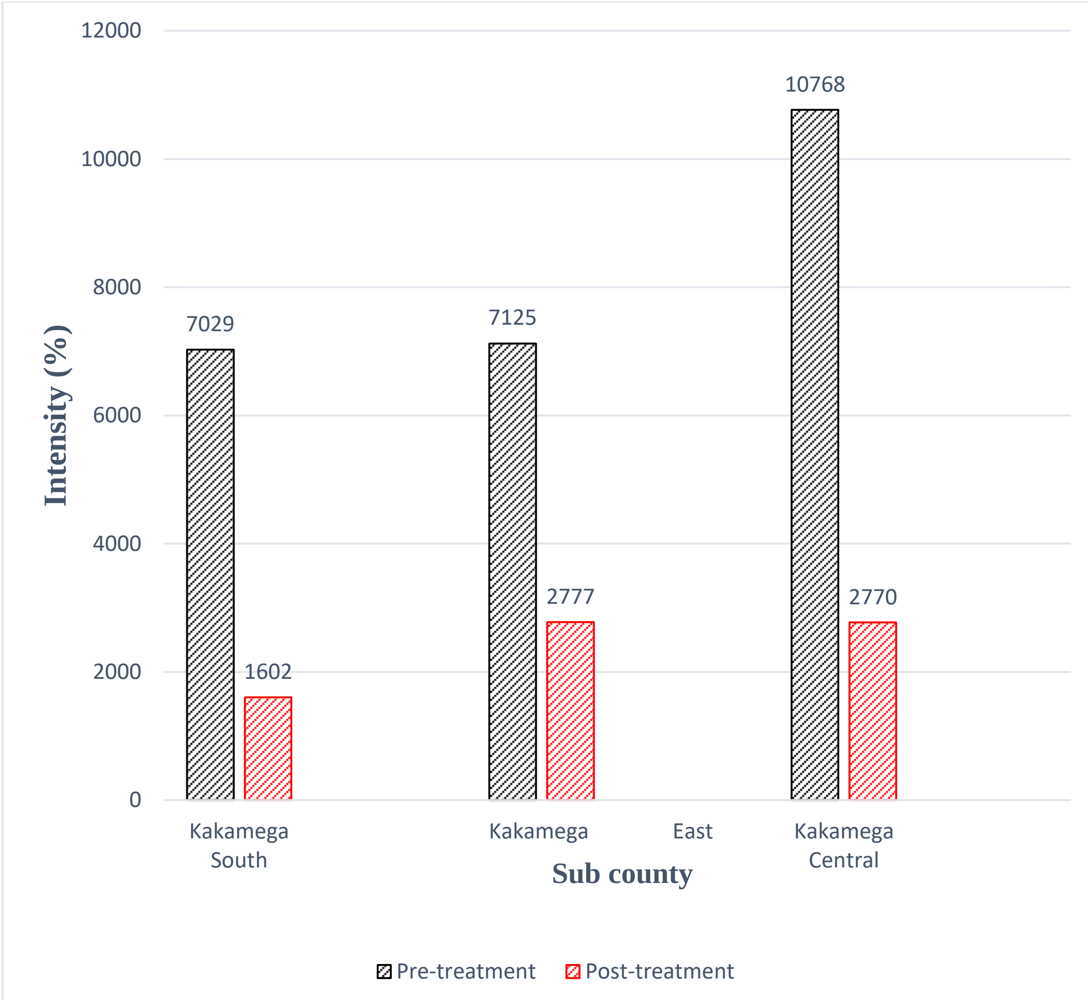

Figure 4.13 Intensity of STN for Pre and Post Treatment by Sub-County

4.10.7 Prevalence of STN Combined for Pre and Post Treatment by Gender

There was high significant difference in prevalence infection reduction among male and female in both pre and post treatment $p<0.001$ (Figure 4.14).

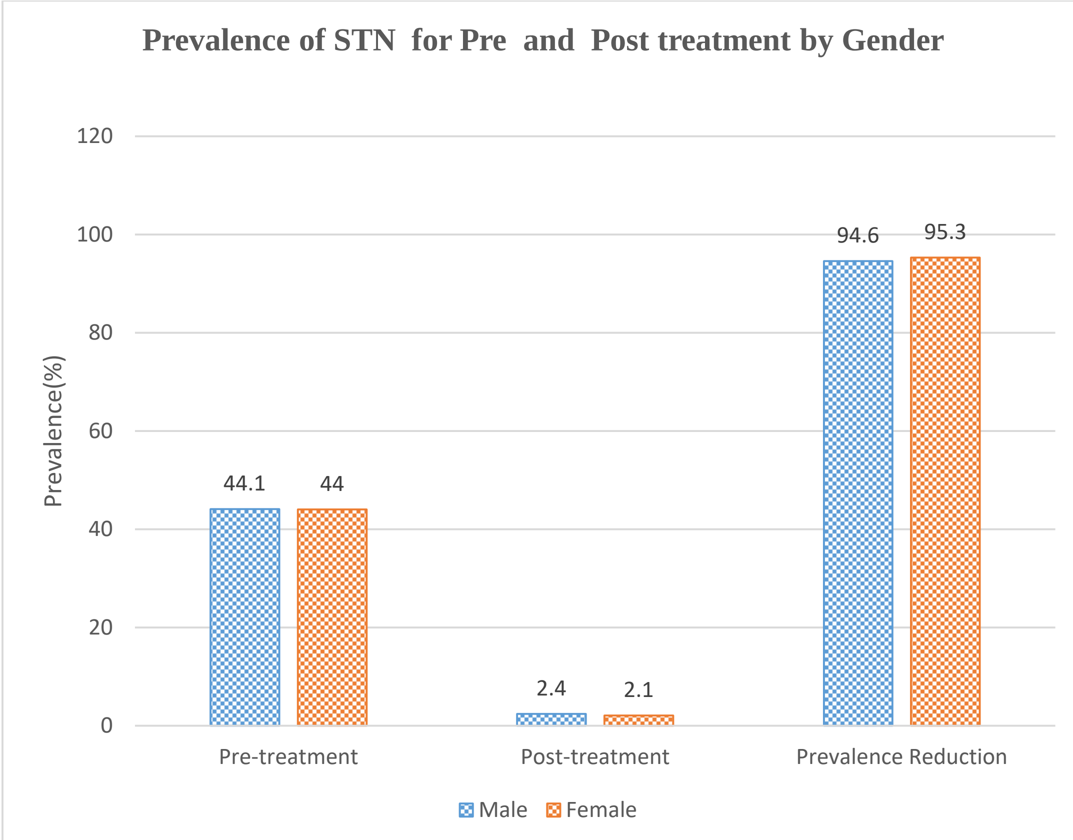

Figure 4.14 Distribution of Overall Prevalence of STN Combined for Pre & Post Treatment by Gender

4.10.8 Intensity of STN Combined for Pre & Post Treatment by Gender

Mean intensity of STN Combined differed significantly between Pre- Treatment & Post –Treatment, $p<0.001$. Unlike in pre-treatment where female had high intensity of STN, post treatment showed female had lower intensity of infection than male, (Figure 4.15). There was significant egg reduction rate between pretreatment and post-treatment ($p=0.001$) (Figure 4. 15).

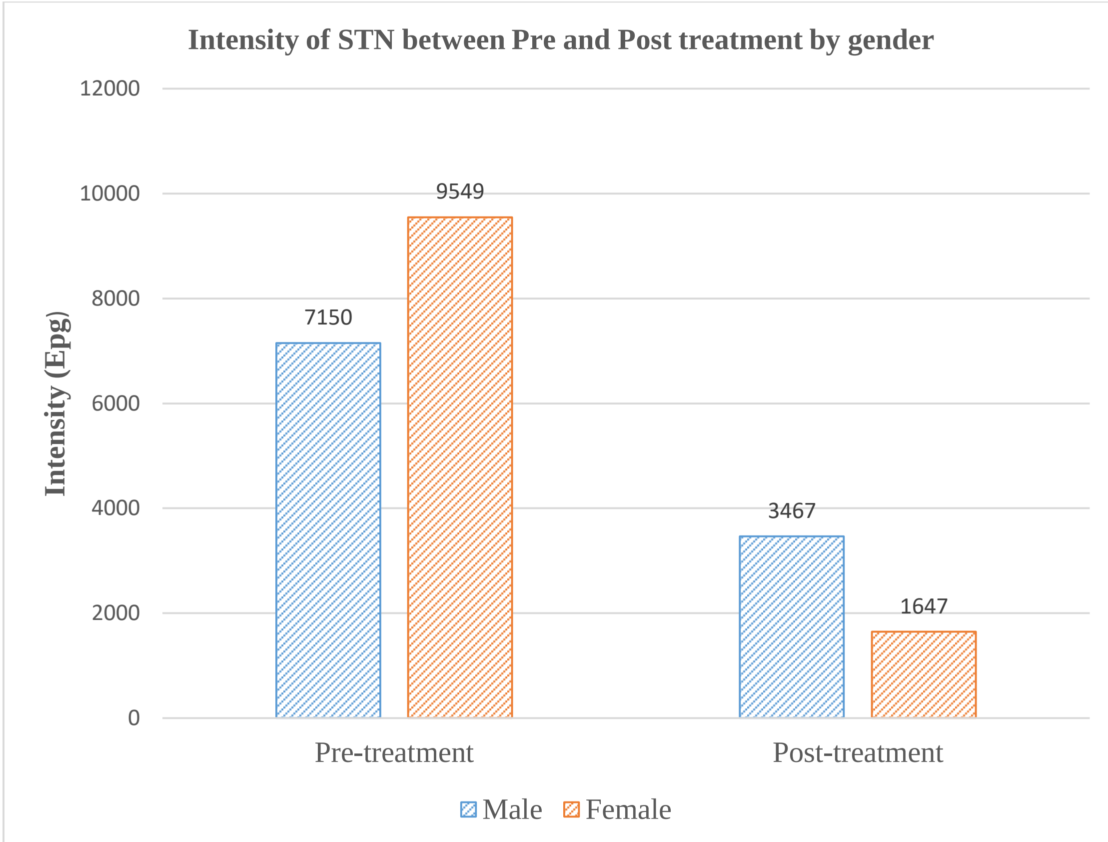

Figure 4.15 Distribution of Intensity of STN in Pre and Post treatment by gender

4.10.9 Prevalence of STN Combined for Pre & Post Treatment by Age

Prevalence of STN Combined differed highly significantly between Pre- Treatment & Post –Treatment in 8-9 years, 10-11 and 12-13 years age brackets ($p<0.001$) (Figure 4. 16).

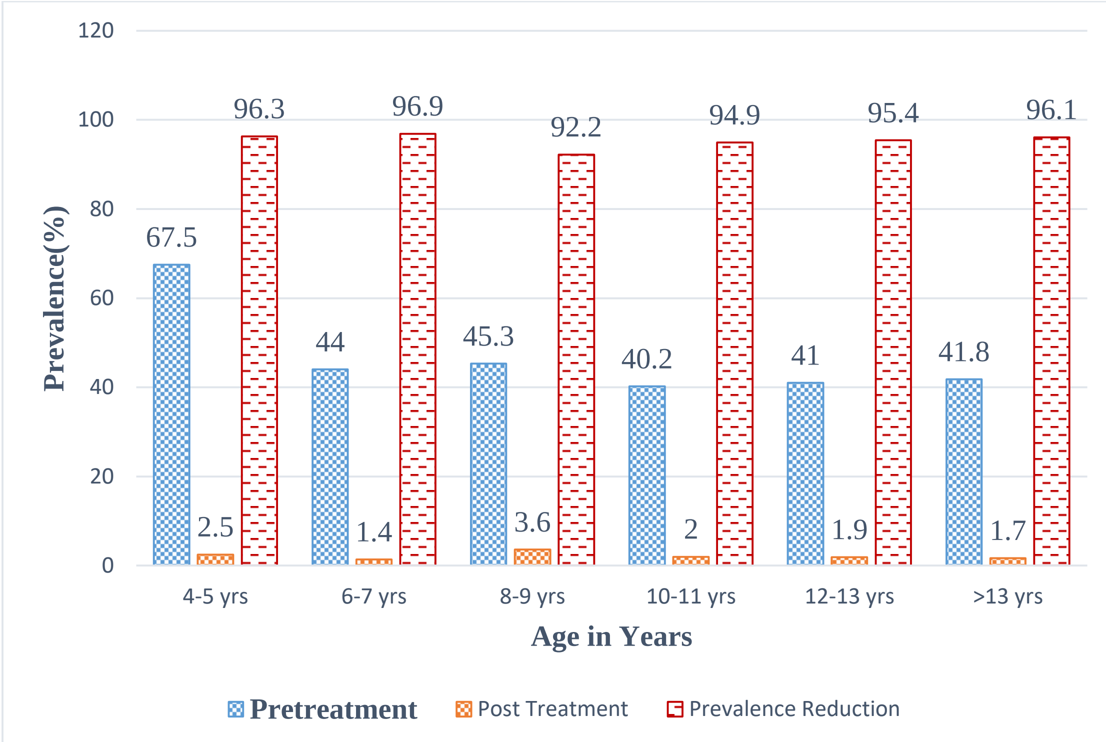

Figure 4.16 Distribution of STN Pre and Post treatment by Age

4.10.10. STN Combined Intensity for Pre & Post Treatment by Age

Children in all the age brackets had highly significant reduction between pre-treatment and post treatment mean intensity p<0.001 (Table 4.9).

Table 4.10 Distribution of Overall STN Intensity Pre & Post Treatment by Age

	Pre-treatment Intensity(epg)	***Post-treatment Intensity(epg)***	**ERR**	**p value**
4-5 yrs	8913(4740-16761)	0	100 %***	[P= 0.001]
6-7 yrs	10752(6778-17055)	0	100%***	[P= 0.001]
8-9 yrs	8654(6954-10770)	2050 (1290-3256)	98.2%***	[P= 0.001]
10-11 yrs	6837(5349-8738)	4884(2232-10686)	96.4%***	[P= 0.001]
12-13 yrs	9217(6888-12333)	1612(772-3365)	99.2%***	[P= 0.001]
Above 13 yrs	6044(3943-9264)	0	100%***	[P= 0.001]

ERR -Egg Reduction Rate ***indicates p<0.001.

4.10.11 Light -moderate intensity of infection of Soil Transmitted Nematodes

STNs infections were predominantly of light infections post treatment. For STN combined, there were significant reduction in light and moderate intensity (Table 3.2) of infections of 92.1% (p=0.001) and 98.5% (p<0.001) respectively (Table 4.9). For hookworm and *T. trichiura*, there were no moderate intensity of infection, while light intensity increased non-significantly by 9.8% (p=0.944) for hookworm. There was significant reduction by 99.2% (p<0.001) for *Trichuris trichiura* (Table 4.9). In *Ascaris lumbricoides,* there was significant reduction both in light and moderate infection, after intervention, with 91.9% (p<0.001) and 98.5% egg reduction rate (p=0.001) for light and moderate intensity of infections respectively (Table 4.9).

Table 4.11 Prevalence of light, and moderate of infection % (95%CI)

	Level of Infection	
	Light infection	**Moderate Infection**
STN combined		
Pre-treatment	24.6(20.1-30.1)	19.4(14.1-26.7)
Post-treatment	2.0(1.1-3.5)	0.3(0.1-1.0)
ERR	92.1%(p=0.001)	98.5%(p=0.001)
Hook worm		
Pre- treatment	0.3(0-1.9)	0
Post- treatment	0.3(0-1.1)	0
ERR	Increase [9.8%, p=0.944]	**
A. lumbricoides		
Pre- treatment	24.1(19.7-29.4)	19.4(14.1-26.7)
Post- treatment	2.0(1.1-3.5)	0.3(0.1-1.0)
ERR	91.9%(p=0.001)	98.5% (p=0.001
T. trichiura		
Pre- treatment	0.8(0.4-1.8)	0
Post- treatment	0	0
ERR	99.2%(p=0.001)	**

** There was no epg that recorded moderate infection

ERR - Egg Reduction Rate

Light & Moderate infection (Table 3.2).

CHAPTER FIVE: DISCUSSION, CONCLUSIONS AND RECOMMENDATION

5.1 Discussion

The mean age of children recruited in the study was 10 years (SD = 2.6 years) with age range of 4 years to 16 years. The children were recruited from from Early Childhood Development, up to class six. Few of the children had their age above 14 years (UNICEF, 2009). This could be attributed to the open access to free primary education for alI. Children from low resource background, who may be previously not attending school, may join at an older age (Lucas, 2012).

5.1.1 Baseline Prevalence and Intensity of Soil Transmitted Nematodes

The baseline prevalence of Soil transmitted nematodes was (44.05 %). These findings show Kakamega county remain an endemic area. This prevalence though was high was within WHO range bracket that is recommended for annual deworming of those at risks population with 20%- 50 % prevalence (WHO, 2019). In Nairobi Kenya, a similar study found prevalence of 40.7% in PSAC and SAC of slum villages (Davis *et al.,* 2014). In Nigeria, Kola *et al.,* (2017) found a lower prevalence of 34.8%. In the same country, another study recorded a higher prevalence of 54.8% (Karshima *et al.,* 2018). In Ecuador another study found prevalence to be lower at 29 % (Moncayo *et al.,* 2018). The prevalence of Soil Transmitted Nematodes in the current study showed the population in this area had high infestation which could be contributed by high environmental contamination and inadequate hygiene practices by the school going children.

Soil Transmitted Nematodes are prevalent among people especially children. Majority of. the infected children from the present study (44.04%) were infected with only one parasitic nematode species. Children with single infection are better placed to have improved academic scores than with multiple infections (Ranjan *et al.,* 2015).

The findings of the present study showed STN prevalence (44.05%). This was higher than in India (39%) with hookworm 38% and *Ascaris lumbricoides* 1.5% (Kaliappan *et al*., 2013). It is also noted that current results are much higher than what was found in a study from selected schools across Kenya with a reported (32%) prevalence (Okoyo *et al*., 2016). Schools from some endemic areas could have high STN prevalence than those under National Deworming monitoring program. A study by Handzel *et al*., (2003) found a high prevalence of 63% STN prevalence in Western Kenya.

The findings of present study were however much lower than what was observed in Nigeria where the highest prevalence of intestinal parasites was 97.8% while the least prevalence was 67.4% in rural quranic schools (Damen *et al.,* 2011). Different STN infections prevalence varies in different areas depending on exposure to risks factors that may increase the rate of transmission.

The current study had a higher prevalence than what was found in Mbita, Kenya. Ngetich *et al.,* (2016) found highest STN prevalence was 6.8 % in Mbita sub county. The age bracket (4-16 years) in the current study corresponds with the peak of STNs infection (WHO, 2012); unlike the 3-84 years age of the study subjects in Mbita which may have contributed to the low STN infections. The current study showed that there could be feacal contamination in the region and this could probably explain the high prevalence of STN among the school going children (Steinbaum *et al.*, 2016). Exposure to feacal contamination poses a substantial health risk in children (George *et al.,* 2015).

There is need to have all the schools in endemic areas included in monitoring programme instead of selected few (Okoyo *et al.,* 2016). This would give the stake holders the actual status of the STN infections in the country. The results of the baseline study had prevalence of *Ascaris lumbricoides* (43.5%) as the most common STN, followed by *Trichuris trichiura* (0.82%) and hookworm the least (0.27%). The children population had high *Ascaris lumbricoides* infection indicating its higher occurrence and transmission more than the other identified nematodes. This is similar to other world reports that *Ascaris lumbricoides* is more prevalent Soil transmitted nematodes (De Silva *et al*., 2003; Hotez *et al.,* 2008) whereas in Western Highlands, Akhwale *et al.,* (2004) found as low 10% of *Ascaris lumbricoides* prevalence.This could be explained by different transmission dynamics such as level of contamination for each specific human soil nematode in different areas. This concurs with other studies that found *Ascaris lumbricoides* as the most common STN (Albonico *et al*., 2008; Nyakang'o *et al*., 2015; Kumar *et al.,* 2014). However, the results are different with what was found elsewhere in Kenya, in Nyanza, Owiti. (2007) reported STN prevalence of 18.4% among school children. The current findings reiterates that the study area has high transmission of *Ascaris lumbricoides* more than hookworm and *T. trichiura,* an indication that there is high enviromental contamination with *Ascaris lumbricoides* eggs in the area. Prevalence of *T. trichiuris* in this study is lower than that of another study done in Ethiopia (42.3%), (Fikresilasie, 2011).

Shitaho primary stood out with highest prevalence (62.6%) of STN among all the schools. The locality of this school is on the outskirts of Kakamega town in a peri urban locality. This is similar with other studies that reported prevalence rates of Soil Transmitted

Nematodes higher in peri-urban area (Utzinger *et al.,* 2006; Jex *et al*., 2011). The results of the present study differ from what was found by Suchdev *et al.,* (2014) in Nairobi schools where prevalence of School Age Children (SAC) was 40.7%. Such variations in prevalence of helminth infections in the current study, could be attributable to several risk factors. This could be due poor personal hygiene, environmental sanitation, urbanization, human behavior, household clustering, occupation and climate. This observation is supported with the known fact from Brooker *et al.,* (2009), that there is considerable regional variation in the presence of human soil nematodes infections in East Africa.

These findings are similar to Kepha *et al*., (2015) who found that STN infections are still prevalent in Western Kenya despite the on-going deworming programme. The results of the present study sharply contrast with what was observed elsewhere in Kenya. This study found far much higher prevalence than what was reported in the neighboring Kisumu East, in Nyanza County (17.4%) and 18% in Kilindini Sub County in Mombasa County (Brooker *et al*., 2000; Odiere *et al*., 2011). The major STNs detected in children was *Ascaris lumbricoides*, followed by *Trichuris trichiura* which had very low prevalence (0.82%) and hookworm with 0.27%. A study from a Southern Ethiopia village found *Trichuris trichiura* as the most prevalent (82.9%) (Nyantekyi *et al*., 2010). Elsewhere, Pullan *et al.* (2014) observed that *Ascaris lumbricoides* infection was most common STN infection in some parts Africa and Asia. The notable difference in prevalence of the three nematodes in the current study could be due to different transmission dynamics conditions of each identified nematode.

There was low *Trichuris trichiura* prevalence in Bukhulanya, Matende, Bukusi and Shina primary schools. This showed a remarkable decrement in the prevalence of parasitic infections. The progress in reduction of the parasites prevalence could have been due to different interventions that have been undertaken in the area like national school based deworming and health education. None of the participants in Shitaho, Shina and Shamsinjili primary schools were infected with *Trichuris trichiura*. This compares to Kaliappan *et al.,* (2013) and Odinaka *et al.,* (2015) studies that showed no infection of *Trichuris trichiura* in India and Nigeria respectively. They further stated that, geographical factors could favour *Trichuris trichiura* in some areas and not others. This could apply to these schools in the current study.

In the present study, the surveys coincided to the dry season and this could have contributed to low prevalence of this nematode. *Trichuris trichiura* eggs require shade and enough soil moisture, with ambient temperatures which protects eggs from desiccation and needed for the eggs development. Absence of *Trichuris trichiura* infection in some of the schools might be attributable to environmental conditions that were unfavourable of eggs development. This study compare with another in Tanzania, which observed a decrease in *Trichuris trichiura* infection prevalence (Manz *et al.,* 2017).

In this study, *Trichuris trichiura* infections were quite low as compared to the *Ascaris* and hookworm infection. This is consistent with what was observed by Osazuwa *et al.,* (2011) and Okoyo *et al.,* (2016) in Kenya, but different to findings in other studies. Handzel *et al.,* (2003) in Western Kenya and Njanake *et al.,* (2012) in Coastal Kenya studies indicated higher prevalence of *Trichuris trichiura*. It is not clear why there was such a low prevalence because environment and climatic factors may not explain such a notable difference. Therefore, further studies need to be conducted maybe with larger sample size to ascertain other factors associated with this condition.

Hookworm infection prevalence was the least among the three STNs identified in the current study (0.27%). Such a low prevalence in the current study could be due to less contact with infective hookworm larvae in the study area. Perhaps increased hookworm transmission during the rainy season could be associated with increased farming activities and probably rains dispersing faecal matter increasing chances of parasite contact with humans (Odinaka *et al.*, 2015). What was observed in this study could be attributed to dry season at the commencement of the study. Seasonal variations in transmission of hookworm infections has been documented to increase during the rainy season (Nwosu, 1981).

This was different with findings of other studies in Kenya. According to Mwandawiro *et al.* (2013) hookworm prevalence in Western Kenya was higher (25.1%) than the other regions (Coast (18.2%), Nyanza (11.8%) and Rift valley (3.5%). Other studies recorded hookworm infection with higher prevalence (15.4%) at baseline survey than in the current study area (Oslen *et al.* 2004; Okoyo *et al.* 2016). Nordin (2009) and Truscot. (2014) also reported that baseline hookworms infection levels were lower than those of *Ascaris lumbricoides.*

The prevalence of STN combined and any single STNs didn't vary markedly between male and female participants. These results concurred with those from a study conducted in Turkey that showed that there was no statistically significant difference between the prevalence of intestinal worms and gender (Topcu, 2001). It was also similar to what was found at Wendo, Ethiopia where, 39.3% of the males and 35.6% of the females had STN infections, and there was no significant association between gender and infection of the parasite (Fikresilasie *at el*., 2011).

Prevalence of STN observed in 4-5 years age group was significantly high (67.5%) compared to other age groups (p=0.049), whereas, the intensity of STN combined was higher though not-significant in the age groups (6-7) years and (12-13) years 10,752 epg and 9,217 epg respectively (p=0.0603). It is possible the age group of 4-5 years could be more exposed to contamination hence the observed number of children with high prevalence. The 6-7 years and 12-13 year could be more adventurous and be more exposed to the STN infection. These results were different from those of Kibera where 16.2% prevalence among children of 10–18 years in urban slum settings in Nairobi Kenya was reported (Suchdev *et al*., 2014). The age difference could be attributed to different environmental settings in the two studies. The age range of pupils in the current study with high STN infections is lower than that of Kibera which extended up to 18 years. Findings of this study are similar to those of Bumula, Kenya, where *Ascaris lumbricoides* prevalence was highest in children below 9 years (Kepha *et al*., 2015).

There were higher levels of *A. lumbricoides* mean intensity in age groups (6-7) and (12-13) years. Children above 13 years had the least intensity of. *Ascaris lumbricoides* these results compare with a study conducted in Hondrus where children aged 5 to 12 years had a higher percentage of *Ascaris lumbricoides* infections than individuals in the other age groups. However, the prevalence of *Ascaris lumbricoides* varied significantly by age ($p < 0.001$). In Nigeria , Egwunyenga *et al*., (2005) found that majority of the infections were caused by *Ascaris lumbricoides,* followed by hookworms and *Trichuris trichiura*. Prevalence rates recorded in this study showed that, the study area was at a high risk for STNs, hence emphasizing treatment of children using anthelminthic drugs should be regular.

In the current study, *Ascaris lumbricoides* was common in all the schools compared to *Trichuris trichiura* and hookworm. Predominance of *Ascaris lumbricoides* is in consonance with studies in Western Kenya that also established *Ascaris lumbricoides* as the most common STN compared to other worms examined (Nikolay *et al*., 2015; Joshua *et al*., 2016; Okoyo *et al*., 2016). There could be other unknown factors that may influence distribution of STNs infections in an area other than hygiene and physical environmental factors. Each STN species have identified limits in terms of high or low land surface temperatures that influence transmission (Pullan *et al.*, 2012). Some studies have suggested that temperature, soil and moisture play a vital role in distribution of STNs (Mabaso *et al*., 2003). Elsewhere, prevalence of STNs ranges from 11% to 82% in rural and urban settings, indicating significant geographic variations (Blaszkowska *et al*., 2011).

In the current study, *Ascaris lumbricoides* was undisputedly the dominant infection in all the schools. Elsewhere, prevalence of *Ascaris lumbricoides* ranges from as low as 36% (in Phillipines rural area) (Allen *et al.*, 2017) to as high as 88% (in Madagascar). In another study, *Ascaris lumbricoides* prevalence among preschool children was 20% in Kenya (Albonico *et al*., 2008). The high level of prevalence of *Ascaris lumbricoides* among children and its dominant trend across endemic countries suggests that it is the most common cause of helminthiases infecting humans of all age groups. Unhygienic habits such as not washing hands and eating unwashed fruits and vegetables has been quoted as risk factors in the spread of *Ascaris lumbricoides* and *Trichuris ttrichiura* infections among children (Avcioglu *et al.*, 2011).

A lot should be done to establish why *Ascaris lumbricoides* is common STN in western region in Kenya in order to identify hotspots of contamination to strategize on how to reduce and interrupt its transmission. It has been established that, *Ascaris lumbricoides*, infective and embryonated eggs stages, have great capacity for tolerating environmental extremes (Hotez *et al*., 2003). Eggs from *Ascaris* are coated with a mucopolysaccharide that give them adhesive to a wide variety of environmental surfaces; this feature accounts for their adhesiveness to everything including door handles, dust, fruits and vegetables, paper money and coins (Asaolu, 2018).

Co-infections of STNs were not common in the study area. Multiple STN infection not witnessed in this study as in many studies conducted in East Africa (Brooker *et al.*, 2000; Mwandawiro *et al*., 2013). Brooker *et al*. (2000) showed that 26% of children in Busia Kenya were infected with all 3 STNs while 31·1% had 2 type of STNs unlike in the current study. Variation could be as a result of differences that might arise from difference in the study subjects, socio demographic conditions and socio-economic characteristics of study locations. Multiple infection may affect nutritional status of the children because of the combined effect of the different parasites that can deprive the important nutrients of the children.

5.1.2 Post treatment Prevalence of Soil Transmitted Nematodes

In this study, the post treatment prevalence showed a marked cure rate.The combined STN prevalence recorded a decrease to 2.3%, 0%, and 0.3% for, *Ascaris lumbricoides*, *Trichuris trichiura* and, hookworms respectively .This is different with what was observed after two rounds of MDA, where combined STN prevalence dropped to 19.7%; with 15.4%, 5.4% and 1.7% for *Ascaris lumbricoides*, *Trichuris trichiura* and, hookworms respectively (Nikolay *et al*., 2015). The current study recorded lower prevalences an indication that prevalence could have been lowered due to deworming activities in the area (MOH, 2009). The drop of combined STN prevalence is different from Kepha *et al*. (2015) findings that reported at 15 months of ALB treatment follow-up, 9.7% of children still harbored STN infection. The drop could be interpreted by the fact albendazole was effective in most of the study subjects in the currents study with no reinfection. In the present study, post treatment was done after 14 days to avoid any possible reinfection, an indication that the albendazole cleared most of STN infections.

The decline of prevalence of STN in the present study collaborate with prevalence's of STN combined and each specific worm after two times treatment that dropped 16.4, 32.3, 15.4, and 18.1 to 6.7%, 2.3, 11.9 and 4.5 % in STN combined, hookworms, *Ascaris lumbricoides* and *Trichuris trichiura*, respectively (Okoyo *et al.*, 2016). However, the follow up survey in the current study indicate lower prevalence in post treatment with substantial decrease of STN infections, than in the above study. This variation in prevalence could be due to the fact that the current study covered seven schools whereas more schools from different counties in different geographical zones were covered in Okoyo *et al.*, (2016). Time taken between baseline survey (2012) and follow up assessment (2014) was longer (Nikolay *et al*., 2015; Okoyo *et al.*, 2016) than the time between treatment and post treatment survey (14 days) in the current study. This prevented reinfection of STN after treatment which could occur quite fast.

5.1.3 Post treatment Intensity of Soil Transmitted Nematodes

In this study, it was observed that, STN combined (p=0.0603) and *Ascaris lumbricoides* (p=0.0601) had high mean intensity in the 6-7 years and 12-13 years. These findings contrast what was found previously in Pemba Island, where the study showed that, there were lower infection intensities of the three STN in class 5 children. Though not significant, there is need to address the transmission trend and execute measure to control these infections.

Trichuris trichiura and hookworm had quite low intensities and were all in light infection in this study. No immediate explanation could be given for the apparent detection of low intensity. This could be due to few eggs' and infective larval contaminating the environment by the two nematodes in this study area.

Hookworm has a slower rate of infection compared to *Ascaris lumbricoides* because its third stage larvae has shorter life expectancy (3-10days) unlike *Ascaris lumbricoides* eggs with several months infective period (Brooker *et al.*, 2006). This implies perhaps that hookworm infestation to an environment can be eliminated faster than that of *Ascaris lumbricoides*. This could explain the high intensity of *Ascaris lumbricoides* infection in the current study. Reduced intensity of hookworm and *Trichuris trichiura* could also be attributed to improved sanitation provided by presence of latrine and their good structural conditions in all schools and better health services that restrict their transmission. Among all the seven schools, six of them had good latrine conditions. This promote latrine usage by the children lesding to less environmental contamination. School based intervention should be established in order reduce and control STNs infection rates (Bethony *et al.,* 2002). The post treatment marked reduction of STN. Pretreatment findings in the current study is in line with what was observed earlier in certain regions of Kenya after implementation of school deworming programme (Brooker *et al.,* 2002).

However, Kakamega County in Western Kenya has remained a high endemic area. This study did not assess individual risk factors associated with STN. The prevalence of some of STN were high in this area, an indication that transmission is high and could be influenced by conditions that facilitate the development and survival of free-living stages in the external environment (Brooker *et al.,* 2006). Survival of STN free-living stages is dependent on environmental conditions that influence their transmission success. Strunz *et al.* (2014) observed that the rate of exposure to ova and larvae exposure is determined by limited access to water, good sanitation and hygienic behavior.

Intensity of STN in the current study was classified in class of intensity (Montressor *et al*., 1998). Quantification of severity of infection is revealed by classification of the STNs infection into, light, moderate and heavy intensity. This study had light and moderate infections among the children. Light and moderate intensity of infection seemed to occur in most of the infected children and therefore experience morbidity consequences. The infected individuals act as focal points of transmission in the school and community. The present study findings have shown that chemotherapy can reduce the load of nematode infections. To have the success of school deworming programme sustained, other interventions such as sanitation and health education are also required.

It should be noted that, Abendazole drug is largely used in areas of a high infections. Every year, where WHO conducted it's studies using school-based helminth control programs, both ABZ and MBZ have been used (WHO, 2011). The current study recorded varied prevalence and egg reduction rates at baseline and follow up surveys.

5.1.4 Cure Rates of Soil Transmitted Nematodes

This study had ascertained that *Ascaris lumbricodes* and *Trichuris trichiura* infections had significant cure rate respectively (p<0.001). This is similar to findings of other studies. A single dose of 400 mg albendazole was highly effective against *Ascaris lumbricoides* infection, with over 96% cure rate and egg reduction rate over 99.8% (Legesse *et al*., 2002; Inke. 2012). Legesse *et al.* (2004) and Adugna *et al.* (2007) also reported that 400 mg single dose of albendazole had a 92.5% and 83.9% reduction against *Ascaris lumbricoides* respectively. Current findings are however different from what was reported elsewhere in Kenya. According to Kepha *et al*. (2015), 28 % of the children were still infected with STN species after treatment.

In this study, albendazole was effective for both *Ascaris lumbricoides and Trichiuris trichiura* in the present study area and the effect is case specific. *Ascaris lumbicodes* and *Trichuris trichiura* infections after intervention with chewable 400mg albendazole had equal to 95% and 100% cure rate respectievely which is considered satisfactory (WHO, 2013).

Similarly, Prichard *et al.* (2011) had shown that, STN infection prevalence, had 29.2% among the children three weeks post-treatment, while the respective prevalence (2.7 %), (1.7%), (30.2%) was hookworm, *Ascaris lumbricoides* and *Trichuris trichiura* infections respectively. However, findings of present the study supports Bennet and Guyatt. (2000) and Keiser and Utzinger (2008) reports, that indicated a single dose ALB treatment was most effective for infection with hookworm preceded by *Ascaris lumbricoides.*

The current study showed 100% reduction in prevalence for *Trichuris trichiura* from *a* single a dose of albendazole compared to the two other STNs. This differs with a previous study by Bennet *et al*. (2000), where only in a 3- day dosage of albendazole was used to treat *Trichuris trichiura*. However, the prevalence of *Trichuris trichiura* was quite low in this study (0.82%) and this explain its high cure rate.

All the schools had a significant cure rate of STNs in this study. Currently, this study compares with previous baseline survey results where STN infection declined significantly over the years in Kenya particularly in Bunyala region (Brooker *et al.,* 2000 Baird *et al.,* 2011). Another study in Kwale District, in the Coast Province, Kenya, also recorded a decrease in STN infections. This is because during Elimination of Lymphatic Filariasis programme, Diethylcarbamazine citrate (DEC) and albendazole supply were given four times (Ministry of health, 2011, Njenga *et al*., 2011).

Results in this study found that hookworm prevalence increased non-significantly implying albendazole failed to clear the infection. This is similar with a report from Ghana that has indicated a major failure in ALB treatment in hookworm infections. In Ghana, out of infected subjects, Egg Reduction Rate was 82% (Humphries *et al*., 2011). A recent study reported 35% prevalence and 61% Egg Reduction Rate in the same country (Humphries *et al*., 2017).The present study, had low prevalence of hookworm indicating reduced number of infective larvae and, lower reproduction numbers probably due to scanty environmental contamination. The observed increase in hookworm in the current study agrees with what was found by Nikolay (2015) in fifteen schools. The observed increase could be due to failure of the drug to clear the nematode in this area.

The current study recorded hookworm non- significantly increased by 9.8% (P=0.944). Albendazole was not effective on hookworm infections. This could have due to continued exposure to the STNs parasites because of not wearing shoes (Plate 3.1). The same was observed for *Necator americanus* in West Africa (De clercq *et al.,* 1997). Though with different anthelminthic drug, Reynoldson *et al. (*1997) observed that pyrantel resistance in *Ancylostoma duodenale* in Australia. Mebendazole, a benzimendazole like albendazole in this study, failed in treatment of hookworm (WHO, 2002). Humphries *et al*. (2011) also reported that albendazole treatment failure in hookworm, where nearly one third of subjects had higher counts on repeat examination. Without new anthelminthic, hookworms could become difficult to treat in the near future. Different findings were reported in Ethiopia, where 93.7% had no hookworm infection after treatment (Tefra *et al.,* 2017).

The current study recorded *Ascaris lumbricoides* prevalence reduction was 94.8% (P=0.001). This is different with 97% *Ascaris lumbricoides* infections reductions elsewhere in Ethiopia (Fikresilasie *at el*., 2011). Unlike in the present study, the results in Ethiopia, indicated that 400 mg of albendazole as a single dose was highly effective against both *Ascaris lumbricoides* and hookworm infections (Fikresilasie *et al*., 2011). Further surveys require to be conducted in the current study area and assess the treatment regimens or develop new anthelminthic drugs on hookworm (Tcheum *et al.,* 2011).

The current findings on the high effectiveness of ALB on *Trichuris Trichiura,* are supported by (Levecke *et al*., 2012) where his results indicated that effectiveness depend on intensity and a single dose albendazole would be enough in areas of low infection intensity.

Current findings are not consistent with those of other studies where albendazole had low effectiveness against *Trichuris trichiura*, (Vercruysse 2012; Nikolay *et al.,* 2015). Elsewhere, low cure rates of albendazole against *Ascaris* and *Trichuris* were reported in Zanzibar Island among Ungujan children Stothard *et al.,* 2009b. Significant reduction to 100% on a single dose stood out in this study (P=0.001). Unlike in the current study, Olsen *et al.,* (2009), Diawara *et al*., (2013), Keiser and Utzinger (2008) reported that higher dosage treatment of *Trichuris trichiura* was required. A current study in Indonesia reported 12.8% cure rate (Fitria *et al.,* 2017). However, the prevalence of *Trichuris trichiura* was quite low in the current study and this may have contributed to the effectiveness of albendazole against this nematode.

The study shows that *Ascaris lumbricoides* dominated the prevalence rate among all the STN found in the study area. At Pre-treatment, all schools and sub-counties had high prevalence of above 30% except Iyenga primary school which had less than 30%. There was no significant difference in infection among male and female in both pre and post treatment. Children aged 4-5 years showed the highest prevalence (67%) of STN combined than other age groups. This could be due to the high exposure to environmental contamination with parasites eggs or larva and the low immunity in children with this age group.

Results from this study has not reached conclusive evidence on the albendazole failure on STN, but the results suggest warnings on hookworm. This is because in this study, it was observed that hookworm infection non significantly increased instead of reducing in the post treatment. This may be explained by the drug failure to clear all ova in the study subjects. Vercruysse *et al*. (2011) observed the possibility of ALB unable to cure infections during the pre-patent period after the pre-intervention egg count. This could occur in endemic areas where transmission occurs daily because of soil and food contaminated with infective stages of the parasites, and remain in the population uninterrupted during the period study.

Current study, has demonstrated that the there could be other underlying factors where effectiveness of albendazole is doubtful because both *Ascaris* and *Trichuris* were satisfactorily treated in the study. It is important to ensure that ALB tablets are swallowed by all subjects in such a study. This was strictly observed in this study. Vercruysee 2011 speculated that, the few studies that reported reduction in effectiveness of hookworms could be genuine cases of Anthelminth Resistance due to selected parasites resistance alleles' or other confounding factors.

Current observation in this study is doubtful on effect of albendazole on hookworm infection though the increase was non-significant. Elsewhere varied effects of a single dose of ALB raised doubts about the complete effectiveness of the Mass Deworming Programmes targeting on STNs (Adams *et al.,* 2004; Tcheum *et al.,* 2011). However, current study treatment using albendazole shows high effectiveness of prevalence reduction of ascariasis and trichuriasis. Further investigations are required for development of new anthelminths, with improved active contents in treatment regimens. (Speich *et al.,* 2016). What has been observed in this study, may suggest that the single dosage may be not be enough especially in monopoly of using albendazole in some of STNs as previously observed elsewhere (Knopp *et al.,* 2010; Speich *et al.,* 2016). According to WHO, (2008) low dosage may contribute to the development of anthelminthic resistance and therefore future survey should pay attention to this issue.

5.1.5 Soil Transmitted Nematode Egg Reduction Rate

In the present study, ERR was high for both STN combined and *Ascaris lumbricoides* infection (98.4%) $p < 0.001$. *Trichuris trichiura* had ERR of 100% $p < 0.001$. This was similar to what was observed by Fenwick *et al.* (2009) where there was a decrease in the intensity of STN infections. The current study proves that there is effectiveness of ALB against these STNs in the study area. The present study *Trichuris trichiura* ERR is different from another in Indonesia with ERR of 62.4% reported.

Diawara *et al*. (2009) indicated that, *Trichuris trichiura* had varied anthelminthic effectiveness due to the beta-tubulin codon 200 polymorphisms’ absence or presence association with BZ resistance. In addition, Marti *et al*., 1996 had previously observed that, some strains of STN species could have drug tolerance.

The findings of this study on *Trichuris trichiura* prevalence reduction due to few positive cases, are supported by trials in Brazil and Cambodia based on only 1 and 2 positive individuals, respectively (Vercruysse *et al.,* 2011). Wide variation in effectiveness of ALB to *Trichuris trichiura* indicate geographical differences could be confounding factors across regions (Levecke *et al*., 2011a; Levecke *et al*., 2012;

Vercruysse *et al*., 2011). Where prevalences of *Trichuris trichiura* are quite low one dosage of albendazole would still be effective (Levecke *et al*., 2012).

In this study, *Ascaris lumbricoides* Egg Reduction Rate was 98. 4% this was close to ERR of *Ascaris lumbricoides* in seven countries in three continent which was 98.2% (Vercruysse *et al*., 2011). This is in support of the findings in other studies (Keiser and Utzinger (2008); Bennet and Guyatt, 2001). This is an indication that, deworming programmes successively control this parasite. Other interventions are important to curtail reinfection and to sustain interruption of transmission. The 59 epg mean intensity could be attributed to albendazole ovicidal effect and action that could be observed after the treatment (Inke *et al.*, 2012). Post treatment stool observation after 2 weeks treatment was done, in the present study, explaining the possible cause of different cure rate due to albendazole effect on embroynated eggs within 4 weeks in the another study (Inke *et al.*, 2012).

Targeting a population for treatment, such as children in school or other groups with morbidity risk may be an essential factor in determining how fast anthelmintic resistance selection occur (Albonico e*t al.*, 2004b). Breaking the life cycle has also been revealed to be efficient in the control of drug resistance in veterinary parasites (Wolstenholme e*t al*., 2004). This application could be adapted in STNs by providing adequate sanitation and improved water; this would contribute to the reduction of the incidence of infection. Community based and school based mass deworming programs proved to lessen the burden of STN infections.

It is essential to use alternative treatment to avoid or reduce the selection pressure for resistance. First of all, drug combinations with different anthelmintic drugs could delay the selection pressure and increase the drug effectiveness. For instance, it has been shown that pyrantel-oxantel in combination have a high prevalence reduction against hookworms and *T. trichiura* (Albonico *et al*. 2002). Another study reported combined use of anthelminth, levamisole with MBZ, that had high effectiveness than either drug alone (Albonico *et al.* 2003).

The presently observed results differ from many other studies that document a single dose albendazole being unsatisfactory on *Trichuris trichiura* (de Silva, 2003; Olsen, 2007; Appleton *et al.*, 2009; Vercruysse *et al.,* 2011) often requiring several treatments. Findings of this study shows the Pretreatment and Post treatment survey for Hookworm and *Trichuris trichiura* were quite low respectively. The prevalence of these two STNs at the time of the pre and post treatment survey in that area were far less than 50 positives recommended for assessment of anthelminthic drug effectiveness under investigation (Levecke *et al.,* 201la, 2012b; WHO, 2013). For *Ascaris lumbricoides* the positives were above 50 positives and therefore qualified the assessment of drug effectiveness. Size for the current study was within the required range of ERR examination. This is as recommended by Levecke *et al.,* (2011a, 2012b) models which suggested the ERR sample size be above 50 subjects.

5.1.6 Water Sanitaion and Hygiene school factors

Large scale Mass Drug Administration in is not adequate to control STN infections without other complementary intervention. This study observed school WaSH factors during the pretreatment survey. Improved water sources were observed only in (42.9%)

of schools studied. The study results indicate that schools in the Kakamega East did not have improved water source yet they reported lowest prevalence of STN among the three counties. It is evident that other factors may have contributed to the lower prevalence. This could have been due to the lower number of pupils per latrine ratio along with the good latrine structural integrity observed in schools in this Sub County. This indicates that lack of a WaSH facilities in schools can lead to exposure to STN infection. Effect on other improved WaSH facilities minimizes exposure to infections (Cairncross *et al.*, 1996).

Improved water supply is important for improved hygiene practices at school and at home but only aggregated intervention components guarantee reduced STN infections. Elsewhere, reduced impact of hygiene and hand-washing improvements have been lowered by unavailability of water (Gabrie *et al.*, 2014). Notwithstanding the observed scenario that some schools went up to an average of more than 3 months without drinking water is an indication that some schools still sourced water from outside the school exposing children to unsafe water. These sources include, Borehole or well, Rain water, Stream or river, sources whose safety could not be guaranteed. Improved water source in school ensure less contamination hence less STN infections. Furthermore, school children sourcing water from boreholes and wells could take it unboiled/untreated thus enhancing STN infection.

It was observed in this study that maintenance of clean latrines conditions was higher (57.1%) than what was observed in Tana River Delta (4.7 %) (Njaanake et *al.*, 2008). There was significant association between pupil latrine ratio and infection intensity. Lack of enough latrines may lead to pupil’s defeacating or urinating in open field near the latrines. This would lead to more environmental contamination with STN eggs. Access to / use of improved latrines, maintenance and pupil latrine ratio contribute to low STN infections (Freeman *et al.,* 2015). The mean pupil per latrine ratio in the current study was nearly 36:1 just above the Government of Kenya's standard of 30 pupils per latrine (GoK, 2008). This was different from what was observed in another study where there was average ratio 37:1 for girls and 40:1 for boys (Alexanda *et al.,* 2014). Pupils per latrine was associated significantly with STN intensity in the current study. Lack of latrine use facilitates the seeding of the environment with helminth eggs that form the most important means of transmission of STN that would lead to spread of infections to an entire school or village (Bruun & Aagaard-Hansen, 2008).

In the present study, all of the schools had access to latrines and 4 of schools (57.1%) were clean at the time of visit. Latrines usage depends on whether they are clean as evident by previous study where pupils were less likely to use latrines that were in poor sanitary state (Caruso *et al.,* 2014). Maintenance of clean latrines may motivate children to use the latrines at school more frequent. However, clean latrines should be amassed with hand washing in order to reduce contamination (Greene *et al.,* (2012). An impromptu examination of sanitation conditions observed that 5/7 (71.4%) of schools had access to hand washing facility with soap and 4/7 (57.1%) clean latrine conditions. Both covariates have been proved to be associated with decreased STNs infection as witnessed in another study (Ziegelbauer *et al.,* 2012). This study however did not examine the use of hand washing and sanitation facilities but only their availability. Raja *et al.* (2001) noted that the presence, availability, ownership or access to the sanitation facilities does not indeed mean they are used. In this study, it was observed that some of latrines lacked good structural integrity as determined by presence of roof, walls with no holes, a door and stable floor slab similar to (Alexandra *et al*,. 2014).

5.1.7 School WaSH risk factors association with Prevalence and Intensity of STNs Infection

The current study assessed the school WaSH risk factors associated with STN infections that lower STN infection along with effectiveness of albendazole. The risk factors observed were not assessed at individual worm species because of the lower presence of *Trichuris trichiura* and hookworm infections, hence combined STN status was correlated with WaSH risk factors. The main global approach to control morbidity due to soil-transmitted nematodes is preventive chemotherapy. However, combined interventions are necessary in order to reduce STN infections (WHO, 2002).

In the present study most of the WASH factors did not show statistical significance correlation with the STN prevalence and intensity. Based on the study findings, improved water source non significantly lowered STN prevalence (p=0.350) and intensity (p=0.659). The source of water may be an important indicator of the quality and quantity of water accessible to sustain preventive hygiene standards that would lower the transmission of helminth infections (Dumba *et al.,* 2008). Though there was no significant association of improved water source and STNs infections in this study, elsewhere in Kenya improved water source was significantly associated with low STNs infections (Wang *et al.,* 2013; Edelduok *et al.,* 2013). The present study also observed that, availability of drinking water was found to be correlated with lower infection intensity but not prevalence (χ^2 =0.0583, p=0.809). This finding is similar with the study of Gyorkos *et al.,* (2013), where water availability showed significant improvements in STN infections in Peruvian primary school children.

Exposure patterns of STN still exist despite availability of drinking water because it depends on whether the water is treated or not. Water from bore holes, rivers or stream possibly taken unboiled (in schools) and untreated, increases the chances of STN infection. Some of the schools included in this study, are within Kakamega Municipality where there is 10% coverage of piped water and over 300 bore holes and yet the common sanitation system is pit latrine being used by about 97% even within households (Barasa *et al.,* 2015). This confirms that there is inadequate water supply in this study region which is also experienced in schools. Elsewhere lack of sufficient water supply was strongly associated with increase in infection with any STN among school children living on Pacific islands (Hughes *et al.,* 2004).

Source of drinking water in the present study is mostly from boreholes, rivers and streams which is not treated. Water quality and quantity are important aspects for personal hygiene and access to water sources at school level is crucial. This probably supports better access to hand-washing water and cleaning of toilets. Improving schools water quality and quantity, hygiene education, improving latrine hygiene will not only reduce child mortality and STN infections but lead to better health outcomes (Mooijman, 2012).

Sanitation factors observed in this study were pupil latrine ratio, latrine conditions and latrine structural condition. Pupil latrine ratio characterize overall use of latrines in schools. Findings in this study indicate 4/7 (57.1%) had clean latrines. Latrines with good sanitation were not associated with STN prevalence (p= 0.212) and intensity (p=0.659). Though the number of schools per sub county were too few in this study, latrine facility filthiness may discourage some pupils especially girls from latrine use. Therefore, latrine cleanliness becomes significant factor than the pupil to latrine ratio (Freeman *et al.,* 2015).

Unlike in the findings of several other studies, this study used observation to which is objective measure the characteristics facility instead of subjective measures reported by pupils. Cleanliness judgement of pupils may be biased in that they could base it on toilet age, type or structure other than presence of feaces or urine on the floors or on walls (Garn *et al.,* 2017). These observations could be superficial and not depict microbiological cleanliness which could impact differently on STN infections (Freeman *et al.*, 2015).

Hand washing interventions are modest and often most affordable means of WaSH programs that impact on improving child health (Gruijter, 2017). In the present study, presence of hand washing facility with water and soap, though not statistically significant, helped to lower STNs infections prevalence (p=0.495) and (p= 0.809) intensity. Some schools had their hand washing facilities near the classrooms (Plate 4.2) and others close to the latrines (Plate 4.1). This is similar with what was observed in other studies (Xu *et al*., 2001; Bieri et *al.,* 2013; Gyorkos *et al.,* 2013) where hand washing with soap is linked to lessening of STN infections. However, the mere presence of hand washing facilities with soap and water does not interfere with STN transmission without pupils actively practicing hand-washing behaviour.

5.1.8 Summary of the Study

The present study sought to assess effectiveness albendazole among public primary school going pupils. Impact indicators (outcomes) recommended by WHO are the prevalence of soil-transmitted helminths (overall and by species), and the prevalence of the different classes of intensity of infection (WHO, 2017). These indicators are recommended to be collected at baseline and follow up survey (WHO, 2017). In this study, drug effectiveness was examined based on comparison of two main outcomes of STN infections prevalence and intensity in pretreatment and the post-treatment survey. Both outcomes were measured through Kato Katz double slides examination per each stool samples.

At the same time school WaSH factors were recorded during the pretreatment visit to assess their status and availability and whether there was any significant association with prevalence and intensity of STN infections at school level. This was important because complete eradication of Soil Transmitted Nematodes requires not only anthelminthic drug but chief preventive measures such as provision of safe water for drinking and improved toilet facilities alongside public hygiene practices and education to raise awareness on transmission and prevention of STNs.

Pupils' demographics age and gender were recorded and correlated with prevalence and intensity during the pretreatment survey. Two weeks after treatment with albendazole, pupils were examined again to assess for possible post-treatment prevalence and intensity of STN infections. The post-treatment prevalence and intensity were used to obtain prevalence and egg reduction rates to assess effectiveness of albendazole. There is increased use of anthelminthic drugs through school based mass deworming programs, this is suspected to bring a possible occurrence of resistance as observed in animals and human of Africa (Harfoush *et al.,* 2010), South America (Hagel *et al.,* 2008) and Australia (Dobson *et al.,* 2010).

The success of chemotherapy intervention approach to control Soil Transmitted Nematodes in endemic countries like Kenya should continue even if there are reported cases of STN decline on infections in some areas (Jourdan *et al.,* 2017). For this to be achieved, there is need to evaluate who should be treated, how frequently and the role of WaSH in STN control programs. Focus on STN control should go beyond targeting only school children and using preventive chemotherapy alone. Recent studies have observed in Kenya and Phillipines, soil samples (85%) are contaminated with STN eggs (Horiuchi *et al.,* 2013; Steinbaum *et al.,* 2016).

Aiken *et al.* (2015) reassessed school deworming in Kenya. He argued whether deworming is the most cost-effective method on STN and if it actualized the increase of school attendance. The present study endorses implementation of deworming programs because of the reduced prevalence and intensities of STN infection thus decreasing their transmission. The findings in this study are paramount and of interest to public health specialists when identifying transmission breakpoint targets of existing deworming programs.

The data collected gives the current status of prevalence and intensity of Soil Transmitted Nematodes (STNs) infections in Kakamega County. The present study establishes that deworming in Kenya reduces STN infections to substantial lengths that reduces both intensity and prevalence in school children, through prevalence and egg reduction rate.

Children who participated in the study showed a reduction in worm burden after treatment but still there is need to use simple hygiene practices in addition to chemotherapy. It is worth mentioning that the percentage, egg reductions in prevalences in *Ascaris lumbricoides* and *Trichuris trichiura* infections between pretreatment and post treatment were statistically significant. This indicated effectiveness of albendazole against these two nematodes. It is also noteworthy that ascariasis at baseline in all the schools studied were high and control measures tailored towards Ascariasis ought to be put in place. There is need to assess risks factors that contribute to high infections of *Ascaris lumbricoides* in the area.

Findings from this study demonstrated that hookworm and *Trichuris trichiura* were quite low at pretreatment an indication of an outstanding reduction in the prevalence in some of parasitic infections. The progress in the reduction of the parasites prevalence could be due to different interventions that may have been undertaken in the area like national school based deworming and health education. Observed differences between schools may be attributed to the varied domains that define contact with infectious stages. Deworming programme aim at reducing prevalence and morbidity, but, variations in prevalence and intensity were noted in the surveyed schools.

Nevertheless, the exact effect of albendazole on the differences within the 3 STN observed in this study remains inconclusive. We advocate for inclusive approaches giving priority to communities as well because they serve as focal points of STN transmission.

Community based and school based mass deworming programs should be undertaken to reduce the burden of STNS infections.

5.2 Conclusions

Arising from the results of this study it is concluded that-

(i) Pretreatment prevalence of the STN combined was high (44%), and intensity was 3674 epg in the study schools.

(ii) Post treatment prevalence and intensity reduced significantly to 2.3% and 59 epg respectively rejecting the hypothesis that there is no difference between pre and post treatment prevalence and intensity

(iii) Albendazole 400mg effectively reduced STN infections with high cure rate and egg reduction rate of 94.8% and 98.4% respectively. Thus rejecting null hypothesis because albendazole effectively cured *Ascaris lumbricoides Trichuris trichiura*. However, hookworm infection increased non significantly.` `

(iv) Pupil -Latrine ratio was significantly associated with infection intensity of STN infection. This indicates some WASH factors are associated with STN infection.

(v) There was no significant difference between treated water, handwashing facility source of drinking water and prevalence and intensity of STN infection intensity.

5.3 Recommendations

5.3.1 Recommendation from the study

(i). The Ministry of Health and Education should facilitate sustained mass administration of albendazole in the study area to reduce prevalence and intensity.

(ii). The Ministry of Health and Education should promote WASH programmes and health education in schools and in communities to prevent reinfections after treatment.

(iii). School Board of Management should improve sanitation facilities such as latrines and clean water source in schools to reduce STN exposure and infection transmission among children along with Mass Deworming.

(iv). Schools board of management, school committes should ensure the children use the sanitation facilities through health education and sensitization

5.3.2: Recommendation for further research.

From the findings of the present research, further studies are required on,

Ascaris lumbricoides infection and probable risk factors that influence its Transmission in the study area

Effect of albendazole on hookworm infection in the study area need to be addressed further in future in terms of dosage and timing of treatment.

Community based deworming programs on soil transmitted nematodes should be carried out along with school-based deworming programs to enhance their effectiveness and reduce transmission from home environment.

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APPENDICES

Appendix I: Introductory letter.

Project Title: "Effectiveness of albendazole on soil transmitted nematodes among school children in Kakamega County, Kenya*"*.

Introduction: I, Teresia W. Ngonjo; a student at Kenyatta University, Prof. Ephantus Kabiru, Kenyatta University; Dr. Eric Lelo; (KEMRI) in the Centre of Biotechnology and development (CBRD); Charles Mwadawiro ESACIPAC, KEMRI are carrying out a study on Soil transmitted nematode, worms that are transmitted through soil that is feacally contaminated. The purpose of the study is to enable us understand better the effectiveness of Albendazole in treating the parasites, soil transmitted nematodes, and to see if there are changes in treatment caused by albendazole. Even though, medication is available to get rid of the infection in the body, people still continue to pick these parasites. To carry out this study, we need to enroll school children into the study. However, we will need permission from parents/guardians to include their children in the study. From each child included in the study, with permission of the parent/guardian, we will ask for a small amount of stool so that we can check if they have Soil transmitted nematodes. The children found to have Soil transmitted nematodes will be asked to give an additional stool from which we can isolate eggs of parasites for our experiments. All the children found to have Soil transmitted nematodes, intestinal parasites will be given medication to get rid of the infections, free of charge. However, any child found or suspected to have other medical conditions will be referred to the nearest health centre or hospital for medical care, but their parents/guardians will have to meet the medical expenses for these other medical conditions. As a parent/guardian, we requested for permission for your child to take part in this study. Taking part in the study is voluntary and no one can force or influence you to get your child to take part in the study. Even when you give permission, your child can still leave the study, if you or your child decides to do so, at any time, in the future, without suffering any penalty or losing the benefits available for him or her through this study. Please take time to read this information sheet about the study, and when you have read, feel free to ask questions or to seek clarification, now or later, on any issue you do not understand about this study or about your child's participation in the study.

Purpose of the Study: The purpose of this study is to enable us understand better the effectiveness of Albendazole on soil transmitted nematodes.

Procedures to be used: School children, aged 6-15 years whose parents/guardians give written permission for their children to take part in the study will be included in the study. If you give permission, your child will be enrolled in the study, a doctor will examine your child, he or she will then be asked to give a small stool sample to enable us check if he or she has soil transmitted nematodes, If he or she is found to have, we may ask him/her to give some more stool so that we can isolate eggs soil transmitted parasite for use in our experiments. We also want you to know that the eggs or intestinal parasites obtained from the stool your child provides, may be sent to the another Laboratory, where additional analysis and research will be done on the parasite. If your child is found intestinal parasites from the stool examination, he or she receive medication (Albendazole) for the intestinal parasites.

Benefits: Your child is found to have intestinal parasitic infections he/she will receive medication for these ailments, under the supervision of a qualified doctor, free of charge. If other medical conditions are discovered or suspected in your child, he/she will be referred a health centre or a hospital near you, for further medical attention. However, you will be expected to meet the medical expenses for these other ailments, for your child.

Risks, Hazards and Discomforts Associated with the Procedures: Giving stool samples should not cause any harm in your child. The medications your child will receive to treat soil transmitted nematodes & other parasitic infections your child may have, are known to be safe and should not cause any harm. However, in some people, these medications may cause some side effects, which may include dizziness, headaches, and stomach pain, but these, are mild and last only for a brief period.

Confidentiality: The identity and test results of your child will be kept confidential, and he or she will be given an identification number, and your child or results of the tests done will be referred to or identified using the number he or she will be given, even in any correspondence, reports or publications related to this study. All the information and records about your child will remain confidential, and will be kept in a lockable cabinet at KEMRI, and only authorized personnel carrying out this study will have access to these.

Contacts for Further Information: If you need more information about this study, please contact: Teresia Ngonjo, PO Box 1957-10101, Karatina Kenya e-mail ngonjo_teresia@yahoo.com; Prof, E. Kabiru, Kenyatta University, School of Public Health, PO Box 43844,00100, email. ewkabiru@yahoo.com;

Storage, Exportation of Samples and Further Studies: From the stool samples you give, we will remove eggs of intestinal parasites, which we need in our experiments.

Name and Signature (or Thumb Print) of Witness

Appendix II: Informed Consent Agreement for Parents/Guardians

I, Mr./Mrs/Miss ____ being an adult aged 18 years and over, and being the parent/guardian of:___________________________________

Master/Miss (Child's Name)__________Aged____________,who attends School, do hereby give permission to Prof/Dr./Mr./Mrs/Miss for my child to take part in the new study known as "Assessment of anthelminthic effectiveness of albendazole on soil transmitted nematodes among school children in Kakamega county, Kenya" which has been explained to me in _________________________, a language I speak fluently and understand clearly, and now, I know what the study is all about, the tests to be done on my child, the benefits my child will receive for taking part in the study, the medications he/she will be given, if found to be sick with or other intestinal illnesses caused by parasites, the side effects he/she could suffer from the medication, which I have been told, are mild, temporary, and should not cause any harm to my child. I was given an opportunity to ask questions and to seek clarifications of the issues I had not understood clearly about the study, and I am satisfied with the answers and the explanations I was given. I have also, been told that if I have additional questions or concerns about the study later, I can contact the researcher in charge of the study. I accept my child to take part in this study, and agree that he/she can give stool samples for the tests needed in this study. I have been told that my child can leave the study any time he/she decides to do so, and I have been assured that he/she will not suffer any penalty or loss of benefits that he/she should get through this study. All these things have been explained to me and my child in

, a language we speak fluently, and understand clearly. I agree to allow the researchers to remove the eggs of the soil transmitted nematodes parasites from the stool samples my child will give, and they can take these eggs for further investigations and research

Signature (or Thumb Print) of Parent/Guardian

Date

Name of the Person Obtaining Consent and Signature

Name and Signature (or Thumb Print) of Witness

Appendix III: CHILD ASSENT

You are being asked to take part in a study called "Assessment of anthelminthic effectiveness of albendazole on soil transmitted nematodes among school children in Kakamega county, Kenya*"* being carried out by Teresia Ngonjo and researchers from the Kenyatta University and Kenya Medical Research Institute (KEMRI) The purpose of the study is to enable us understand better the effectiveness of Albendazole in treating soill transmitted nematodes and to see if there are changes in treatment of these parasites due to this drug.

If you agree to take part in this study, we will ask you to give stool samples so that we can check to see if you have eggs of soil transmitted nematodes in your body, and also, remove eggs for our experiments. If you are found to have other intestinal parasites, you will be given medication by the doctor to get rid of the soil transmitted nematodes or the other intestinal parasites present in your body, free of charge. We also want you to know that some of the eggs of the soil transmitted nematodes we get from the stool you give, or the adult worms we raise in the lab from the eggs, may be sent to another laboratory, where additional research and analyses of the parasites will be carried out by the researchers. You do not have to give a stool sample for this study, if you don't want to, but there will be no harm if you gave a sample. By giving stool, we can get to check if you have soil transmitted nematodes, intestinal parasites. Also, if you give a sample, we will be able to isolate the soil transmitted nematodes eggs we need for our research. Actually, giving stool samples will not harm you in any way. Do you agree to take part in this study and give stool samples? If you agree to take part in this study and give stool samples, please put a tick (√) next to the answer "YES", in the space given below, and sign your name in the space provided:

YES. I agree to take part in this study and provide stool samples. I also, agree that the researchers can send the eggs of the soil transmitted nematodes they find in the stool sample more analyses and studies.

Name of the Child Signature or Thumb Print

Name of the Person Obtaining Consent and Signature (or Thumb Print)

Name and Signature (or Thumb Print) of the Witness

Appendix IV. CHILD DEMORGRAPHIC INFORMATION

Primary school code

Sub County: [____]____]____]

Child ID
|_____|_____|_____|_____|_____|____|__
__|____|

Primary school name:

name:

Date of visit:

|____|____|/|____|____|/|____|____|
Day Month Year

Student's last Name__________________________

Student's first Name
____

Student's initials

Date of birth
|____|____|/|____|____|/|____|____|
Day Month Year

Age: |_____|_____| years Class |____|

Gender: ☐ Male ☐ Female

Parent/guardian's last name-__________

Parent/guardian's first name__________

SAMPLE COLLECTION

Stool provided:_________☐ Yes ☐ No
Stool slide taken:______ ☐ Yes ☐ No

DEWORMING USE

1. Have you received treatment for worms in the last year?

Read out options, only enter one answer ....[__]
1 = Yes; 2 = No; 3 = Don't know

When was the treatment done, Date.____________________________

2. If yes, where did you receive treatment?

Read out options, only enter one answer ....[__]

1 = School**;** 2 = Health centre; 3 = Home; 4 = Community programme; 5 = Shop; 6= Others *specify* [______________________]

Appendix V: SCHOOL WaSH CONDITIONS AND DEMOGRAPHICS

SCHOOL INFORMATION AND DEMOGRAPHICS

Date of visit: **Day** **Month** **Year**

Sub County Name: ………………………………………………..

Name of school: ………………………………………………..

Gender of pupils: Mixed ☐ Boys ☐ Girls ☐

Name of head teacher: Head teacher phone number:

Name of second contact person (Deputy head teacher or another teacher at school): Second contact phone number:

1. COMPOSITION

i). Total number of schoolchildren Number of girls in the school

Enter 1 =Yes and 0 = No

2. WATER

i). Is there a source of water in the school? Yes □ No □

ii). If Yes, type of water source________________________

iii). Are there water sources close to the school? Yes □ No □

iv).If yes, type of water source________________________

3. **Does the school have any of the following?**

i). Hand washing facilities near the toilets..Yes □ No □

ii). Water in handwashing facilities..Yes □ No □

iii). Soap is available at the hand washing facility ....Yes □ No □

iv). Water available for drinking today...Yes □ No □

4. SANITATION

i). What is the **main** source of water for drinking for students in this school?

Only enter one answer ....Yes □ No □

1=Piped/tap water; 2=Borehole or well; 3=Rain water; 4=Stream, lake or river;
5=Bought; 6=Bottled water;

Latrine sanitation

ii). Are there latrines in the school ……………………………………………Yes □ No □

iii). How many for Boys……………………How many for Girls……………………….

iv). Unlocked and accessible separate toilets for boys and girls……………Yes □ No □

v). Clean latrine……………………………………………………………Yes □ No □

5. Latrine structural conditions

i). Latrine with doors, roof and concrete slab……………………………Yes □ No □

ii. Latrine without doors or roof , earth /wooden slab/…………………Yes □ No □

Appendix V1: Kato – Katz technique standard operating procedures

1. Put the cellophane strip in container having 50% glycerol solution of malachite green for not more than 24 Hours.
2. Take a scrap or newspaper, put a small amount of faeces on to it
3. Press the screen on top of the faecal sample
4. Use a flat applicator stick, and scrape the screen thoroughly on the upper surface of the screen to sieve the faecal sample
5. Take a clean microscope slide and place a template on it.

6. Using the the applicator stick, scoop a little amount of sieved faecal material into the template hole, filling it to level with the applicator stick
7. Carefully remove the template ensuring all the faecal material is left on the slide with none sticking to the template
8. Cover the faecal sample on the slide with a glycerol – soaked cellophane strip
9. Spill over of glycerol if present on the upper surface of the cellophane, should be wiped off using absorbent tissue or toilet paper
10. By inverting the microscope slide, press the faecal sample on a smooth surface against the cellophane onto spread the sample evenly
11. Hold the cellophane and gently turn the microscope slide side
12. Using a microscope examine the slide for Soil-transmitted helminthes eggs.

Appendix VII: Ethical Clearance

KENYATTA UNIVERSITY
ETHICS REVIEW COMMITTEE

Email: kuerc.chairman@ku.ac.ke
kuerc.secretary@ku.ac.ke
Website: www.ku.ac.ke

P. O. Box 43844
Nairobi, 00100
Tel: 8710901/12
Fax: 8711242/8711575

Our Ref: KU/R/COMM/51/304

Date: 31st March, 2014

Teresia Ngonjo,
Department of Community Health,
P.o Box 43844 – 00100
Nairobi.

RE APPLICATION NUMBER PKU/150/I 131 – "EFFECTS OF GENETIC VARIABILITY OF SOIL TRANSMITTED NEMATODES ON EFFICACY OF ALBENDAZOLE AMONG SCHOOL CHILDREN IN KAKAMEGA COUNTY, WESTERN KENYA" – VERSION 2

1. IDENTIFICATION OF PROTOCOL

The application before the committee is with a research topic "Effects of genetic variability of soil transmitted nematodes on efficacy of albendazole among school children in Kakamega County, Western Kenya"- Version 2 dated 7th March, 2014.

2. APPLICANT

Teresia Ngonjo, Department of Community Health,

3. STUDY SITE

Kakamega County, Western Kenya

4. DECISION

The committee has considered the research protocol in accordance with the Kenyatta University Research Policy (section 7.2.1.3) and the Kenyatta University Ethics Review Committee Guidelines **AND APPROVED that the research may proceed for a period of ONE year from 31st March, 2014.**

5. ADVICE/CONDITIONS

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

When replying, kindly quote the application number above.
If you accept the decision reached and advice and conditions given please sign in the space provided below and return to KU-ERC a copy of the letter.

KENYATTA UNIVERSITY OFFICE OF THE CHAIR
31 MAR 2014
ETHICS REVIEW COMMITTEE
P.O. BOX 43844 - 00100 NAIROBI

PROF. NICHOLAS K. GIKONYO
CHAIRMAN ETHICS REVIEW COMMITTEE

I ..TERESIA W. NGONJO.. accept the advice given and will fulfill the conditions therein.

Signature.................... Dated this day of....7/4/2014....... 2014.

cc. Vice-Chancellor
Director: Institute for Research Science and Technology

Appendix VIII: Letter of Approval

(4)

KENYATTA UNIVERSITY
GRADUATE SCHOOL

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

P.O. Box 43844, 00100
NAIROBI, KENYA
Tel. 810901 Ext. 57530

Internal Memo

FROM: Dean, Graduate School **DATE:** 11th May, 2013

TO: Teresia W. Ngonjo **REF:** P97/21879/10
C/o Community Health Department

SUBJECT: APPROVAL OF RESEARCH PROPOSAL

=======================================

This is to inform you that Graduate School Board, at its meeting of 8th May, 2013, approved your Research Proposal for the Ph.D Degree **Entitled, "Effects of Genetic Variability of Soil transmitted Nematodes on Efficacy of Albendazole among School children in Kitui and Machakos Counties, Kenya.**"

Thank you.

DAVID NJOROGE
FOR: DEAN, GRADUATE SCHOOL

KENYATTA UNIVERSITY OFFICE OF DEAN
12 SEP 2013
GRADUATE SCHOOL
P.O. Box 43844-00100 NAIROBI

c.c. Chairman, Department of Community Health

Supervisors:

1. Prof. Ephantus W. Kabiru
   School of Public Health
   KENYATTA UNIVERSITY

2. Dr. Eric Lelo
   Kenya Medical Research Institute
   Centre of Biotechnology Research Development
   Kenya Medical Research Institute
   C/o Department of Community Health
   KENYATTA UNIVERSITY

DNN/rwm

Appendix IX: NACOSTI Letter of Approval

NATIONAL COMMISSION FORSCIENCE,
TECHNOLOGY ANDINNOVATION

Telephone:+254-20-2213471,
2241349,3310571,2219420
Fax:+254-20-318245,318249
Email: dg@nacosti.go.ke
Website : www.nacosti.go.ke
When replying please quote

9thFloor, Utalii House
Uhuru Highway
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No **NACOSTI/P/17/9404/17768**

Date: **31st July, 2017**

Teresia Wambui Ngonjo
Kenyatta University
P.O. Box 43844-00100
NAIROBI.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Assessment of antihelminthic effectiveness of albendazole on soil transmitted nematodes among school children in Kakamega County, Kenya,"*** I am pleased to inform you that you have been authorized to undertake research in **Kakamega County** for the period ending **28th July, 2018.**

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

Kindly note that, as an applicant who has been licensed under the Science, Technology and Innovation Act, 2013 to conduct research in Kenya, you shall deposit **a copy** of the final research report to the Commission within **one year** of completion. The soft copy of the same should be submitted through the Online Research Information System.

GODFREY P. KALERWA MSc., MBA, MKIM
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Kakamega County.

The County Director of Education
Kakamega County.

Appendix X: County Director of Education Kakamega County

MINISTRY OF EDUCATION SCIENCE & TECHNOLOGY

Telephone: 056 - 30411
FAX : 056 – 31307
E-mail : wespropde@yahoo.com
When replying please quote.

COUNTY DIRECTOR OF EDUCATION
KAKAMEGA COUNTY
P. O. BOX 137 - 50100
KAKAMEGA

STATE DEPARTMENT OF EDUCATION

REF:WP/GA/29/17/VOL.III/2028 **10th November, 2017**

Teresia Wambui Ngonjo
Kenyatta University
P. O. Box 43844 – 00100
NAIROBI

RE: RESEARCH AUTHORIZATION

The above has been granted permission By National Commission for Science, Technology and Innovation vide their letter REF: NACOSTI/P/17/9404/17768 dated 31st July, 2017 to carry out research on "**Assessment of antihelminthic effectiveness of albendozole on soil transmitted nematodes among school children in Kakamega County, Kenya**", for a period ending **28th July, 2018.**

Please accord her any necessary assistance she may require.

COUNTY DIRECTOR OF EDUCATION
KAKAMEGA COUNTY

for **FREDRICK M. KIIRU**
CDE/CEB – SECRETARY
KAKAMEGA COUNTY

Appendix XI: County Commissioner Kakamega County

REPUBLIC OF KENYA

THE PRESIDENCY
INTERIOR AND CO-ORDINATION OF NATIONAL GOVERNMENT

Telegrams "DISTRICTER" Kakamega
Telephone 056 -31131
Fax 056 – 31133
Email: cckakamega12@yahoo.com
When replying please quote

COUNTY COMMISSIONER
KAKAMEGA
P O BOX 43 - 50100
KAKAMEGA.

Ref: ED/12/1/VOL.III/60

Date: 10/11/2017

Teresia Wambui Ngonjo
Kenyatta University
P O Box 43844-00100
NAIROBI

RE: RESEARCH AUTHORIZATION

Following your authorization vide letter Ref: NACOSTI/P/17/9404/17768 dated 31st July, 2017 by NACOSTI to undertake research on ***"Assessment of antihelminthic effectiveness of albendazole on soil transmitted nematodes among school children in Kakamega County."***

I am pleased to inform you that you have been authorized to carry out the research on the same.

NZIOKA MUTISO
FOR: COUNTY COMMISSIONER
KAKAMEGA COUNTY

Appendix XII: SCHOOL SURVEY LAB REPORTING FORM (Soil Transmitted Nematode)

Slides (circle): **A / B** Reader (name) ______________ Date / / **School Name: …………………… Code.…...........**

Child ID	HK	AS	TR	SM	Other 1:name	Other 1: count	Notes
01							
02							
03							
04							
05							
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