PREVALENCE OF INTESTINAL PARASITIC INFECTIONS AND ASSOCIATED WATER, SANITATION AND HYGIENE FACTORS AMONG CHILDREN IN SCHOOLS IN MWEA WEST, KIRINYAGA COUNTY, KENYA

ELIZABETH NJAMBI KIMIRI

MASTER OF SCIENCE

(Public Health)

JOMO KENYATTA UNIVERSITY

OF

AGRICULTURE AND TECHNOLOGY

2024

Prevalence of Intestinal Parasitic Infections and Associated Water, Sanitation and Hygiene Factors among Children in Schools in Mwea West, Kirinyaga County, Kenya

Elizabeth Njambi Kimiri

A Thesis Submitted in Partial Fulfilment of the Requirements for the Degree of Master of Science in Public Health of the Jomo Kenyatta University of Agriculture and Technology

2024

DECLARATION

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

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

Elizabeth Njambi Kimiri

This thesis has been submitted for examination with our approval as the University Supervisors

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

Dr. Dennis Magu, PhD

JKUAT, Kenya

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

Prof. Sammy Njenga, PhD

KEMRI, Kenya

DEDICATION

For my family, Robert my life partner and Jerusha my sweet little girl!

ACKNOWLEDGEMENT

I take this opportunity to thank the Almighty God for the free gift of life, care, intellect, wisdom and grace during my time of carrying out this project.

My supervisors, Dr. Dennis Magu JKUAT and Prof. Sammy Njenga of ESACIPAC, KEMRI for having believed in me and given me the opportunity to carry out this study. I also thank for them for their guidance and contribution towards fulfilling the requirements of this degree. I wish to thank the Dr. Collins Okoyo of ESACIPAC, KEMRI for his immense guidance in data analysis and manuscript development.

My sincere appreciation to the staff at JKUAT School of Public and KEMRI Graduate School who are always helpful in sorting out any challenges I was going through.

I thank my wonderful parents Josephine and Peter Kimiri for their unwavering prayers, love and care. I can never thank you enough! My wonderful partner and husband Mugambi, you are an inspiration, my siblings Miriam, Wycliffe and Isaac for your friendship and kid jesting has brought joy and encouragement during this period. Finally, my mum Nyokabi, has my deepest appreciation for the love, consistent encouragement, guidance during this period.

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ACRONYMS AND ABBREVIATIONS

CITI	Collaborative Institutional Training Initiative
CSC	Centre Scientific Steering Committee
epg	Eggs per Gram
ESACIPAC	Eastern and Southern Africa Centre for International Parasite Control
IPI	Intestinal Parasitic Infections
JMP	Joint Monitoring Programme
KEMRI	Kenya Medical Research Institute
MDA	Mass Drug Administration
MDGs	Millennium Development Goals
MOE	Ministry of Education
MOPHS	Ministry of Public Health and Sanitation
SBD	School Based Deworming
SERU	Scientific Ethics and Research Unit
STATA	Statistical Software for Data Science
STH	Soil Transmitted Helminths
UNICEF	United Nations Children's Fund
VIP	Ventilated Improved Pit latrine
WASH	Water, Sanitation and Hygiene.
WHO	World Health Organization

DEFINITION OF OPERATIONAL TERMS

Domestic domain The area occupied by a household.

Public domain Includes public places of work, education, commerce and recreation.

Improved water sources This source adequately protects water from outside contamination particularly fecal matter. These were piped water into dwelling, piped water into yard/plot, public tap or standpipe, borehole, protected well or spring, bottled water and rain water.

Improved sanitation A facility that hygienically separates human excreta from contact with the environment. These were flush toilet, toilet connected to a piped sewer system, toilet connected to a septic system, flush to a pit latrine, ventilated improved pit latrine (VIP), pit latrine with slab and composting toilet.

Open defecation This is disposal of human feaces in fields, forests, bushes, open bodies of water or other open spaces.

Wiping material Material used for anal cleansing including schoolbook paper, leaves, grasses, stones, corncobs and one's own hands.

Intestinal parasitic infections These are infections caused by intestinal parasites and occur when humans ingest or have contact with contaminated water.

Polyparasitism These are infection with more than one parasite species, a common occurrence in intestinal parasitic infections.

ABSTRACT

Intestinal parasites are prevalent infections in developing countries causing significant morbidity and mortality if not detected and treated. Infections are associated with lack of access to safe water, adequate sanitation and poor hygiene practices and school children bear a significant burden of the infections. The main objective of the study was to determine the prevalence of parasitic infections and associated water, sanitation and hygiene (WASH) factors. This was a cross-sectional survey conducted in Mwea West and 180 primary school children aged 8-14 years were randomly selected from three primary schools (Mianya, Mbui Njeru and Mukou primary schools) to participate in the study. The main method for data collection was questionnaires (WASH factors) and laboratory examinations of stool samples (*Schistosoma mansoni*, Soil transmitted helminths and intestinal protozoan infections). Data were analyzed using descriptive statistics to give proportions and mean. Associations were determined using logistic regression reporting the crude and adjusted odds ratio (OR and aOR) at 95% confidence intervals. Results showed that the overall prevalence of *S. mansoni* and intestinal protozoan infections was 70.5% (95%CI: 59.1-84.3) and 32.7% (95%CI: 26.8-40.1) respectively. Only one case of STH (*A. lumbricoides*) was identified. An increased prevalence of *S. mansoni* infection was associated with children above 12 years (3.19(95%CI:1.25-8.14) p=0.015) and may be attributed to their playing and hygiene habits that increase exposure to infections. Thirty five percent (35.6%) of the households utilized improved sources of water for drinking and domestic purposes while 64.4% utilized unimproved water sources and contact with canal and river water was reported at 160 (88.9%). Among the three schools, Mianya primary had the greatest odds of *S. mansoni* infection (1.23(95%CI:1.14-1.32) p=0.001) due to close proximity to River Thiba that is known to harbour snail vectors. This study concluded that infections with *S. mansoni*, any protozoa and their coinfection are a public health problem in Mwea West. The findings recommend that Ministry of Health and county governments should develop strategies that combine deworming efforts and improved WASH to combat parasitic infections.

CHAPTER ONE

INTRODUCTION

1.1 Epidemiology of Intestinal Parasitic Infections

Intestinal parasitic infections are a major public health concern in developing countries with children being the most affected (Abossie & Seid, 2014; WHO, 2002). These infections which are prevalent among people of low socio-economic status are associated with lack of sanitation, lack of access to safe water and improper hygiene (WHO, 2002). In addition to these factors, a low level of awareness resulting in poor hygiene habits leads to children aged between 5 to 15 years suffering the highest infection rates (Alelign *et al*., 2015; Okyay *et al*., 2004). These infections have been associated with malnutrition and iron-deficiency anaemia and adversely affect the physical and mental development in children (Brooker *et al*., 2006). They also destroy tissues and organs, cause abdominal pain, diarrhea and other health problems (Abossie & Seid, 2014). These infections are caused by soil transmitted helminths (STH), *Schistosoma mansoni* and intestinal protozoan parasites. Transmission of these infections occurs primarily via the fecal-oral route through consumption of contaminated food and water (CDC - Parasites - Parasitic Transmission, 2023). In addition, contact with contaminated soil and fresh water bodies harboring infective forms of the parasite leads to human transmission of hookworms and *S. mansoni* infections respectively (Matthys *et al*., 2011).

Worldwide, around two billion people are infected with intestinal parasites and about 12% of the global disease burden is observed among school-age children (Hailegebriel, 2017; Mehraj *et al*., 2008). *Ascaris lumbricoides, Trichuris trichiura* and hookworm which are collectively termed soil transmitted helminths (STHs) are the most common intestinal parasites. Globally, *A. lumbricoides* infections are 1.2 billion people, *T. trichiura* infects 785 million people and hookworm infects 740 million people (Hailegebriel, 2017). . Infections are most prevalent in tropical and sub-tropical regions of developing countries such as Africa, East-Asia, India, South America, parts of China (Brooker *et al*., 2006). In these developing countries, more than 173 million people are infected with *A. lumbricoides* while 198 million and 162 million people are infected with hookworms and *T. trichiura* respectively (G. Alemu *et al*., 2019).

Approximately, 240 million people are infected with schistosomiasis worldwide and more than 700 million people live in endemic areas. In sub – Saharan Africa, over three million deaths occur annually due to schistosomiasis (WHO, 2002; Workineh *et al*., 2019). In Kenya, an estimated 17.4 million people are at risk of schistosomiasis and 9.1 million people are in danger of STH infections (Chadeka *et al*., 2017). For intestinal protozoa, *Giardia intestinalis* and *Entamoeba histolytica* are the most prevalent protozoan parasites. *G. intestinalis* causing giardiasis is the most prevalent protozoan parasite worldwide with about 200 million people currently infected (Mehraj *et al*., 2008). Globally, intestinal amoebiasis caused by E. histolytica account for 11, 300 deaths and was ranked fourth in the most fatal parasite related deaths (Erismann *et al*., 2016). The estimated prevalence for giardiasis is 2.0 - 7.0% in developed countries and 20.0 - 30.0% in most developing countries.

In sub-Saharan Africa, an estimated 89.9 million school age children were infected with STH infections (Brooker *et al*., 2006). Infections with *A. lumbricoides* were 35.4 million, *T. trichiura* species was 40.1 million and hookworm species was 41.1 million. Due to the similarities in parasite transmission mechanism, many children have multiple infections (Freeman *et al*., 2015). In additions, a large proportion of children under 14 years are affected by schistosomiasis including at least 25 million preschool-age children and in these younger children the prevalence may be greater than 60% (WHO, 2017). In Kenya, out of the six million people at risk of schistosomiasis, 70% are children aged between five to fourteen years. A national mass fecal examination conducted in Kenya established that prevalence of STH worms was 56.8% in school children (Kabaka & Kisia, 2011). For schistosomiasis infections, high areas of transmission are communities residing along the Coast, Lake Victoria and parts Central Kenya (Chadeka *et al*., 2017; Gichuki *et al*., 2019). Although information on spatial distribution of intestinal protozoa in Africa is scarce, it is known that infections are more prevalent in tropic and sub-tropics (Berhe *et al*., 2018; Speich *et al*., 2013).

Studies have revealed that factors influencing the spread of IPIs were largely centred in the family (domestic) and a heavy parasite burden in one person was usually associated with heavy infections in others of the same household (Freeman *et al.*, 2015). This suggested that parasites were largely transmitted within and between family members. This transmission played an important role in spread of disease beyond the physical confines of the household. It was documented that a single case of feacal-oral disease could lead to an outbreak if the patient was allowed to go to public areas. This led to the conclusion that transmission routes could be divided into domestic and public domain. Children due to the nature of their play and poor hygiene habits are important for introduction of intestinal parasites to their local environments therefore maintaining transmission (Mbae *et al*., 2013). The risk of transmission has been observed to be higher where there was crowding of children due to increased person-to-person transmission and environmental contamination. In 2002, Kenya introduced free primary education (FPE) resulting in a rapid increase in the number of children attending school. Consequently, hygiene and sanitation facilities in schools has become strained and may even worsen the infection rates in the school children (Kabaka & Kisia, 2011; Mbae *et al*., 2013).

1.2 Access to Water, Sanitation and Hygiene (WASH)

Access to improved water sources, sanitation facilities and safe hygiene practices in the community is recognized as a human right according to the Millennium Development Goals (MDG's). Goal 7 targeted to halve by 2015, the proportion of people without sustainable access to safe drinking-water and basic sanitation (WHO & UNICEF, 2013). According to Joint Monitoring Programme, water sources are grouped as improved or unimproved. Improved sources refer to: piped water into dwelling, public tap/standpipe, borehole, protected dug well, spring and rainwater collection. Unimproved sources refer to: unprotected dug well, spring, cart with small tank/drum, tanker truck, surface water (river, dam, lake, pond, stream, canal, irrigation channel).

By 2013, the ratio of the population with access to an improved drinking water source in sub-Saharan Africa was reported as 1:0.6 in urban and rural areas respectively. A similar trend was reported in the Kenyan population (1:0.7). The use of unimproved water sources was still a problem and reported as 1: 3.1 in urban and rural population respectively (WHO & UNICEF, 2013). A baseline survey conducted in 22 Kenyan districts in Nairobi and Mombasa, 343 schools were sampled, of which 37.3% had safe water sources in the school yard for drinking and washing hands (WASH in School, 2013). Sanitation facilities can be grouped as improved or unimproved facilities. Improved facilities ensure separation of feaces from human contact. They include flush/pour flush, ventilated improved pit (VIP) latrine, pit latrine with slab and composting toilet. Unimproved facilities refer to; pit latrines without a slab or platform, hanging latrines, bucket latrines and shared sanitation facilities (for two or more households).

Sanitation coverage was lowest in sub-Saharan Africa and access to an improved sanitation facility was reported as 1:0.6 in the urban and rural populations respectively. The use of unimproved sanitation facilities was reported as 1: 0.8 respectively. In Kenya the use of sanitation facilities is described by (WHO & UNICEF, 2013) .Functional sanitation facilities in rural schools are pit latrines while ventilated improved pit latrines (VIP) are used in urban schools. The recommended pupil: latrine ratio in school for girls and boys is 25:1 and 30:1 respectively (WASH in School, 2013). In 2007, UNICEF reported the national pupil: toilet ratio was 38:1 and 32:1 for boys and girls respectively in public schools. It was noted that many schools had a ratio of 100:1 as compared to the recommended maximum of 30:1.

In a baseline survey of 343 Kenyan schools in informal urban settlements of Nairobi and Mombasa, 86.9% had separate latrines for girls, boys and school personnel. Less than a quarter of the schools met the country standards for the number of latrines for boys (20.1%) and for girls (19.0%). Out of the schools surveyed, 62.4% met the criteria for spacious cubicles and 75.8% met the criteria for privacy. Only 32 schools (9.3%) met the minimum hygiene criteria and just over a quarter (27.1%) were observed to maintain their latrines correctly (WASH in School, 2013). Improvements in hygiene behaviour reduce risk of exposure to diseases.

Among school children, hands are an important mode of transmission of infectious diseases. Therefore, simple hand washing with soap helps to protect children from the two common global pediatric killers (diarrhea and lower respiratory infection). Handwashing reduces illness-related school absence rate in elementary students by 26% (Assefa & Kumie, 2014). Critical times for hand washing include: after toilet use, before eating, after cleaning a child and before handling food. Provision of infrastructure (water and sanitation facilities) is not enough to bring down morbidity and mortality rates. This is because hygiene behavior is important in transmission of infectious diseases. These provisions coupled with good hygiene behavior has been proven to be effective in reducing these infectious diseases (Assefa & Kumie, 2014) .

1.3 Statement of the Problem

Parasitic infections are a public health concern in Kenya especially among children in schools. These infections in children can lead to impaired mental and physical development, reduce school attendance and performance, cause anaemia, growth stunting and severe cases can lead to intestinal obstruction (Brooker *et al*., 2006). These infections are known to reoccur as demonstrated by different studies (Kihara *et al*., 2007; Okech *et al*., 2008). In 2015, prevalence of parasitic infections among school children in the study site was determined to be 50.6%, this was despite the implementation of MDA in the region. The study conducted in 2015 was done 3 years after the withdrawal of MDA and was evidence of infection re-occurrence after stopping MDA (Masaku *et al.*, 2015). The provision of safe drinking water, hygiene and sanitation has been recognized as an important factor driving the transmission of intestinal parasitic infections (WHO, 2011). Previous studies have determined association of parasitic infections and the WASH factors at home. This proposed study sought to determine the prevalence of infections among the school children in Mwea, and further investigate the WASH status at both homes and schools of the children and the establish the magnitude of association between the prevalence and the WASH factors.

1.4 Justification

Parasitic infections are a public health concern in Kenya especially among children in schools. These infections in children can lead to impaired mental and physical development, reduce school attendance and performance, cause anaemia, growth stunting and severe cases can lead to intestinal obstruction (Brooker *et al*., 2006). Studies have demonstrated that chemotherapy should be complemented with WASH strategies to effectively control transmission of infections (Masaku *et al*., 2015, 2020). Due to the impact caused by infections and reinfections in vulnerable populations (school aged children), this study was necessary to determine the prevalence of intestinal infections in the study area four years after MDA withdrawal, to determine the existing WASH status associated with parasitic infections. The findings would inform the Ministries of Health and Education and county government on the prevalence and the associated factors with a view to developing appropriate strategies to combat parasitic infections.

1.5 Objectives

1.5.1 General Objective

To determine the prevalence of intestinal parasitic infections and associated water, sanitation and hygiene (WASH) factors among children attending primary schools in Mwea West District.

1.5.2 Specific Objectives

1. To establish the prevalence of *S. mansoni* and intestinal protozoan infections among children attending primary schools in Mwea.
2. To determine WASH factors at the homes and schools of the primary school children.
3. To determine the sociodemographic and WASH factors associated with *S. mansoni* and intestinal protozoa infections in children attending primary schools in Mwea.

CHAPTER TWO

LITERATURE REVIEW

2.1 Prevalence of Intestinal Parasitic Infections

2.1.1 Schistosomiasis

Schistosomiasis is a human parasitic disease predominant in tropical and subtropical areas with limited access to safe water and adequate sanitation. Globally, more than 200 million people, 111 million school-aged children (SAC) and 95 million adults, are estimated to be at risk (Sassa *et al.*, 2020). Schistosomes exists in many developing countries in Africa, Asia, South America and several Caribbean islands (Nelwan, 2019). There are two major forms of schistosomiasis of public health importance: intestinal and urogenital. *S. mansoni* predominantly occurring in sub-Saharan Africa. Urogenital schistosomiasis is mainly caused by S. haematobium and is distributed throughout Africa and the Middle East. Intestinal schistosomiasis is mainly caused by three species, *S. mansoni*, S. japonicum, and S. mekongi and primarily affects intestine and liver through acute and chronic inflammation against parasite eggs produced by adult worms (Gryseels *et al.*, 2006). *S. mansoni* is transmitted to human by ingesting feacal contaminated water/food while *S. haematobium* by skin penetration when in contact with snail infested infected water as shown in Figure 2.1. The life cycle of this parasites involves two hosts: snails and is transmitted through humans contact with contaminated snail infested water.

Seventy six (76) endemic regions are affected and Kenya was ranked among the 10 highest burden countries in the African region (Savioli *et al*., 2012). The two (2) main species of schistosomiasis in Kenya are *S. mansoni* (intestinal) and S. haematobium (urogenital) with approximately 2.5 million people feared to be at risk of infection. In Kenya, schistosomiasis occurs mostly in western, coast, and selected foci in central part of the country (Masaku *et al.*, 2015). Infections are categorized based on the number of eggs per gram of feaces (epg) for *S. mansoni* or eggs in 10ml urine for *S. haematobium*). For *S. mansoni*, 1–99 epg is categorized as a light infection, 100–399 epg signifying a moderate infection and ≥400 epg is a heavy infection (Wiegand *et al.*, 2021). Prevalence of moderate to heavy infections necessitate treatment interventions because they can lead to significant morbidities.

Schistosomiasis has adverse effects on the overall health, school attendance and academic performance of school age children particularly in developing countries. Schistosomiasis has been known to contribute significantly to lower social economic conditions in areas where it is endemic and causes a great deal of disability thus reducing the work performance among the infected individuals (Gichuki *et al*., 2019). Two methods are available to control schistosomiasis: prevention and treatment. Presently, schistosomiasis control strategies focus on mass drug administration of praziquantel (PZQ) in affected communities, with special emphasis on treating school age children (Masaku *et al*., 2015). However, individuals are readily re-infected when exposed again after treatment. Eliminating snail hosts and improving sanitation are important methods to prevent schistosomiasis (Nelwan, 2019). A clean water supply, sanitation, vector control, and health education can interrupt the spread of schistosomiasis.

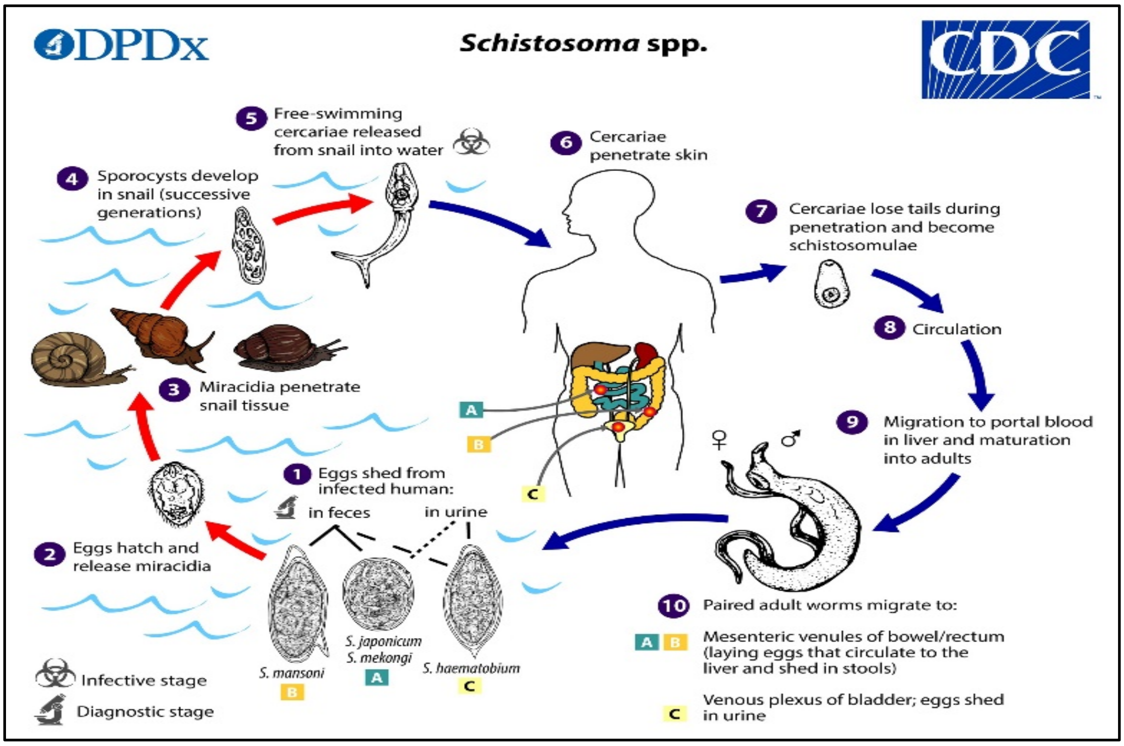


Figure 2.1: Life Cycle of Schistosomiasis Infection

2.1.2 Soil Transmitted Helminths (STHs)

Soil transmitted helminths s refer to infections with Ascaris lumbricoides, hookworms (A*ncylostoma duodenale* and *Necator americanus*) and *T. trichiura*. According to WHO, these infections are among the most common in the world with an estimated 1.5 billion infected people or 24% of the world's population. The highest burden has been reported from sub-Saharan Africa, China, South America and Asia (WHO, 2023). Globally, over 260 million preschool-age children and 654 million school-age children are at risk of infections that lead to morbidities. In these developing countries including sub- Saharan Africa, more than 173 million people are infected with *A. lumbricoides* while 198 million and 162 million people are infected with hookworms and *T. trichiura* respectively (G. Alemu *et al*., 2019). In Kenya, approximately 10 million people are infected with STHs while over 12 million people in rural areas are at risk of infections (Clements *et al*., 2010)

Infection with STHs is transmitted either through the fecal oral route by ingesting food contaminated with eggs. (*A. lumbricoides* and *T.trichiura*) or skin penetration (hookworms) as shown in Figure 2.2. STH eggs are passed in feaces of infected persons, ingested leading to infection and in the case of hookworm, the eggs hatch to produce infective larvae that penetrates the skin leading to infection (CDC - Parasites, 2023).

The intensity of STH infections referring to the number of worms determines manifestation of morbidities (WHO, 2023). People with light infections usually have non symptoms, however, heavy infections can cause a range of symptoms including intestinal manifestations (diarrhoea and abdominal pain), malnutrition, general malaise and weakness, and impaired growth and physical development. Infections of very high intensity can cause intestinal obstruction that should be treated surgically. The control strategy of STHs is chemotherapy and improvement of sanitation, drinking water, use of pit latrines instead of open defecation, and good hygiene practices. Chemotherapy is through MDAs administered to entire communities in endemic areas as recommended by WHO using Albendazole and Mebendazole (Y. Alemu *et al*., 2022).

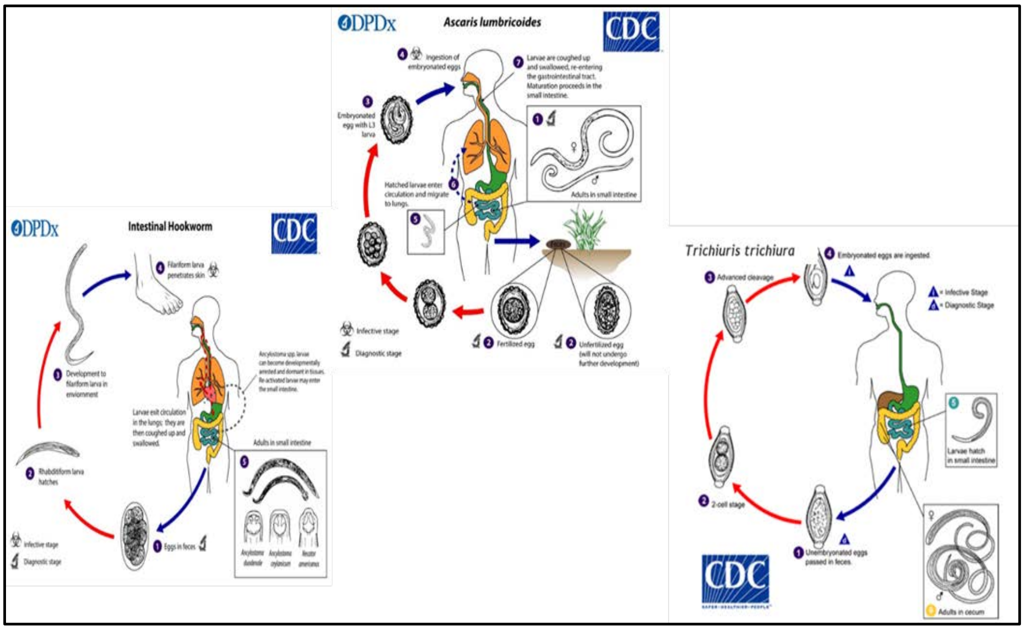


Figure 2.2: Life cycle of STHs (*A. lumbriocoides, T. trichiura* and Hookworm)

2.1.3 Intestinal Protozoa

Pathogenic intestinal protozoa of public health concern are caused by *Entamoeba histolytica* and Giardia intestinalis. Infections may result in gastrointestinal morbidity, malnutrition and mortality worldwide, particularly among young children in developing countries (Speich *et al*., 2013). Amoebiasis caused by E. histolytica is the third leading cause of death from parasitic disease (Stanley, 2003). The estimated worldwide prevalence is 500 million cases of symptomatic disease, and 40.000-110.000 deaths annually (Hegazi *et al*., 2013). There are little data on the true prevalence and incidence of *Entamoeba histolytica* infection in Africa. This is due to the inability, historically, to differentiate *E. histolytica* from the more common, but non-pathogenic, *E. dispar* (Stauffer *et al*., 2006). *E. histolytica* infection is mainly transmitted via ingestion of water or food contaminated by faeces containing *E. histolytica* cysts (Nasrallah *et al*., 2022) (Figure 2.3).

G. intestinalis/G. lamblia infection is endemic worldwide and young children bear the significant burden of the infection. Among children in developing countries, the prevalence rate of 10-50% has been reported (Al-Mekhlafi *et al*., 2013). Giardiasis occurs by the ingestion of cysts in contaminated water, food, or by the fecal-oral route (CDC - DPDx - Giardiasis, 2021) and is the main cause of diarrhea among young children (Al-Mekhlafi *et al*., 2013) (Figure 2.3). Giardia infection manifests as acute or chronic diarrhea or may be present as an asymptomatic infection. Patients suffering from acute infection present with diarrhoea, abdominal pain and the clinical manifestations of malabsorption (Berkman *et al*., 2002). For both species of intestinal protozoa, transmission is frequently associated with contaminated food and water, therefore lack of access to clean water, sanitation and hygiene are strong drivers for infection with intestinal protozoa (Hegazi *et al*., 2013). Treatment of intestinal protozoa is mostly by administering metronidazole, tinidazole, albendazole among other nitoimidazole compounds (Speich *et al*., 2013).

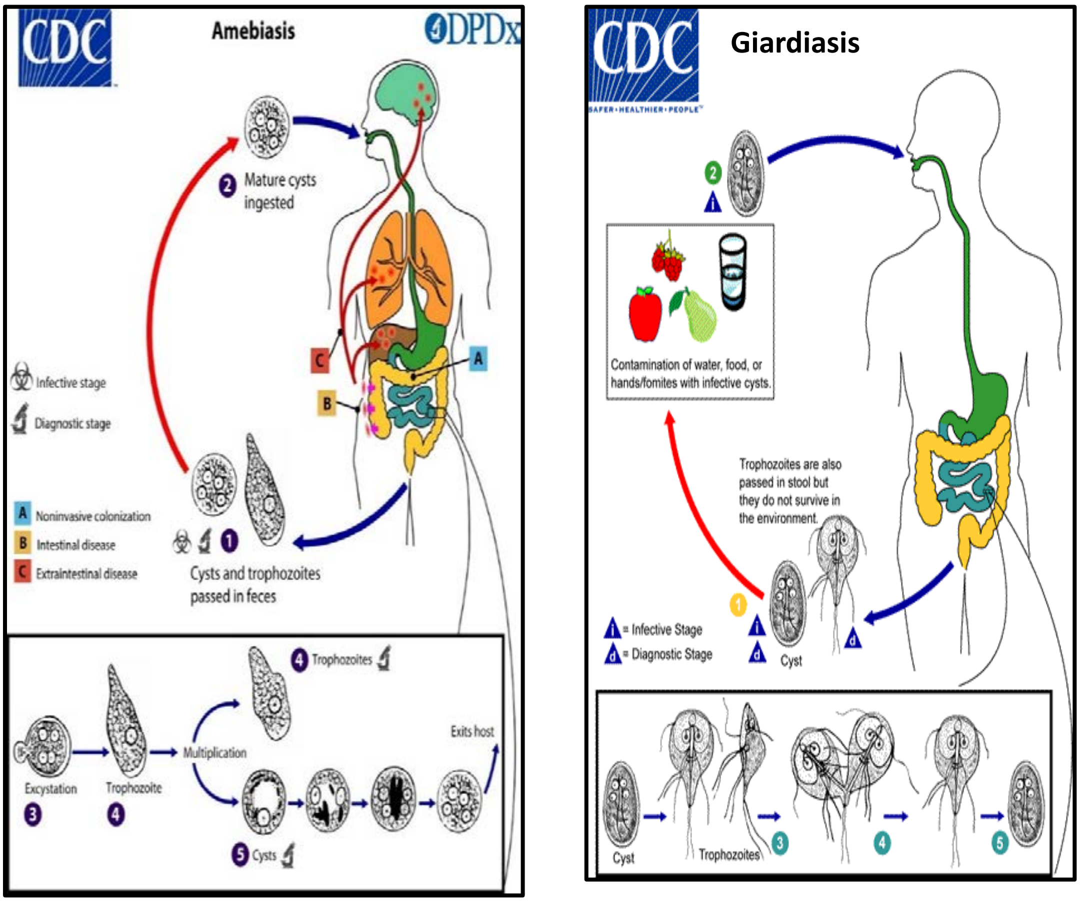


Figure 2.3: Life Cycle of Intestinal Protozoa

2.2 Access to Water, Sanitation and Hygiene (WASH)

Children due to the nature of their play and poor hygiene habits are important for introduction of intestinal parasites to their local environments therefore maintaining transmission. The risk of transmission has been observed to be higher where there was crowding of children due to increased person-to-person transmission and environmental contamination (Mbae et al. 2013). In 2002, Kenya introduced free primary education (FPE) resulting in a rapid increase in the number of children attending school. Consequently, hygiene and sanitation facilities in schools has become strained and may even worsen the IPI rates in the school children (Kabaka and Kisia 2011) (Mbae et al. 2013).

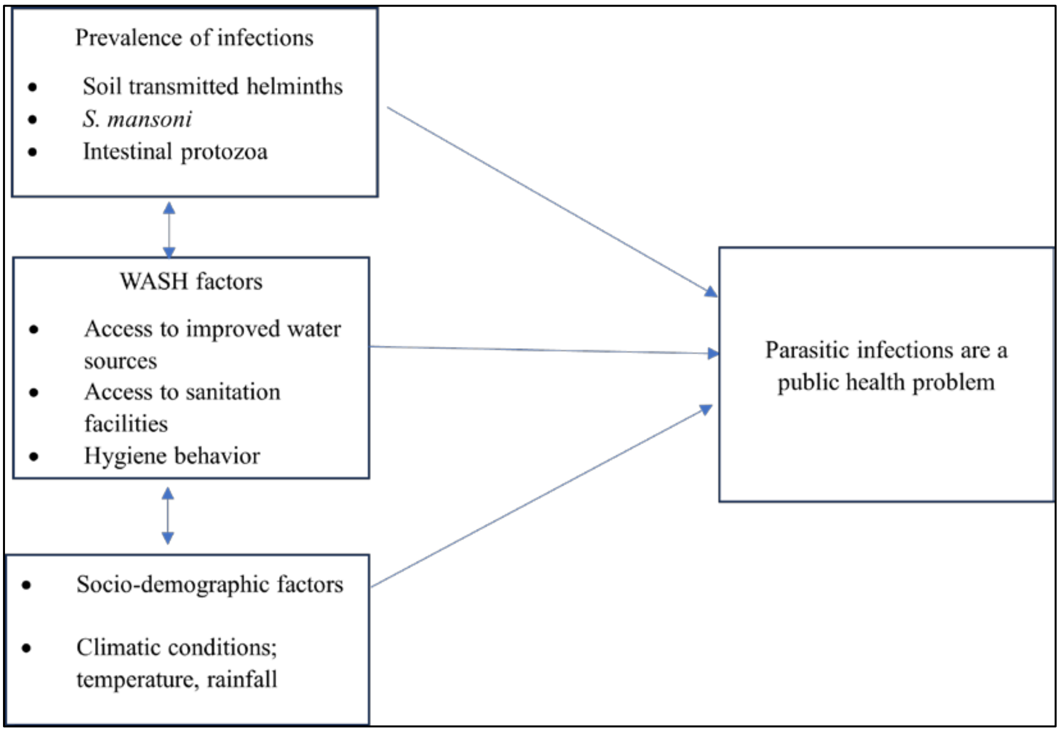
Deworming alone is not enough to control infections and must be coupled with provision of water and sanitation infrastructure as well as proper hygiene behavior (Assefa and Kumie, 2014; Masaku *et al.*, 2015). Sanitation as an intervention is likely to be effective in controlling worm infestations. These facilities interrupt the transmission of feacal–oral disease at its most important source by preventing human fecal contamination of water and soil. Epidemiological evidence reveal that sanitation is at least as effective in preventing disease as improved water supply (Abossie and Seid, 2014).

By 2013, the ratio of the population with access to an improved drinking water source in sub-Saharan Africa was reported as 1:0.6 in urban and rural areas respectively while use of unimproved water sources was reported as 1: 3.1 in urban and rural population respectively (WHO/UNICEF, 2013). A similar trend was reported in the Kenyan population (1:0.7). A baseline survey conducted in 22 Kenyan districts in Nairobi and Mombasa, 343 schools were sampled, of which 37.3% had safe water sources in the school yard for drinking and washing hands (WASH in School, 2013). Sanitation coverage was lowest in sub-Saharan Africa and access to an improved sanitation facility was reported as 1:0.6 in the urban and rural populations respectively. The use of unimproved sanitation facilities was reported as 1: 0.8 respectively.

Attitudes, knowledge, and beliefs are directly linked to hygiene behavior. Having poor knowledge, practice and attitudes to personal hygiene have negative consequences for a child’s long term hygiene behavior (Assefa and Kumie 2014). In Ethiopia, it was established that 60% of children surveyed did not know about the possible transmission of diseases through human waste (Kumie and Ali 2005). The level of awareness of health benefits of hygiene behavior is important in determining the degree of sustainability of such an intervention.

Children did not practice the handwashing knowledge they acquired due to absence of hygiene enabling facilities at school and home (Aiello et al. 2008). It has been reported that as few as 2-7% of schools in low-income countries provide soap for children (Greene et al. 2012). (World Bank 2009), (Dube and January 2012). Lack of resources (soap and water), inadequate sanitation facilities and location of hand washing stations may be the main reasons why children do not wash their hands (Oswald et al. 2008) (World Bank 2009) (Dube and January 2012). The main barriers for latrine use included inadequate number of facilities, limited accessibility, lack of constant water supply and maintenance by school management (Le et al. 2012). In Kenya, barriers included inadequate water, toilets for both boys and girls and ineffective control of vectors, vermin and rodents (MOPHS and MOE 2015).

2.3 Conceptual Framework



The conceptual framework below is focused on the major factors that are associated with IPI infection in primary school children (Figure 2.4)

Figure 2.4: Conceptual Framework of Interaction of Variables

CHAPTER THREE

MATERIALS AND METHODS

3.1 Research design

This was a cross-sectional study using quantitative research methods of data collection and analysis. Structured questionnaires and direct observations using checklists were used to collect data at home and school.

3.2 Study Site

The study was conducted in Mwea West, Kirinyaga County. The county is located about 100 km Northeast of Nairobi, Kenya. It covers an area of 513 km^2, it is estimated to have 51,444 households and a total population of 176,261 people. There are 58,970 school age children aged 5–19 years in Mwea (GoK, 2010). Children sampled were from three schools that were purposively selected based on their proximity to River Thiba and Nyamindi (Figure 3.1).

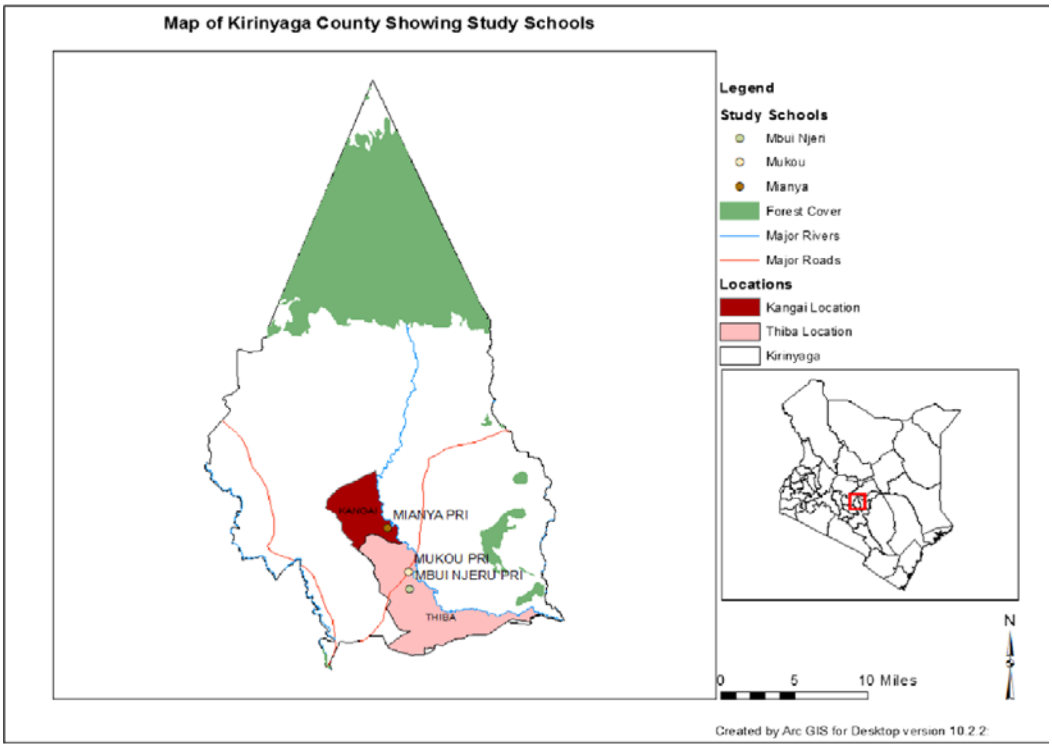


Figure 3.1: Geographical Location of the Study School

3.3 Study population

The study participants consisted of primary school children in standard 2 – 6 aged between 8 – 14 years. According to WHO, this group was among those considered highly vulnerable to IPI's due to their playful nature, eating and poor hygiene habits (WHO, 2002). They are also able to comprehend questions asked and provide the relevant responses.

3.3.1 Exclusion and Inclusion Criteria

Inclusion Criteria

- Children with signed informed consent forms from parents/guardians
- Children who provided stool samples.
- Children aged between 8-14 years.

Exclusion Criteria

- Children who did not have signed informed consent forms.
- Those who did not provide a stool sample/respond to the questionnaire.

3.4 Sampling

3.4.1 Sample Size Determination

The sample size was calculated using Fischer's formula (1998) as follows:

n = (〖z〗^2 p (1-p))/d^2

Where:

z = 1.96; the value corresponding to the 95% level of significance,

p=12.0%; A conservative value of 12% was taken because studies carried out in Mwea show that STH prevalence ranged from 10 – 18% (Njomo *et al*., 2014)

d=0.05 is the allowable error margin.

Therefore, $\frac{1.96^2 \times 0.12(1-0.12)}{0.05^2}$= 162 children

To account for attrition/refusals/inability to produce stool specimen when required, the sample size was inflated by 10% to obtain a minimum sample of size 180 school children.

Purposive selection of schools was based on World Health Organization (WHO) guidelines for STH and schistosomiasis surveys in schools implementing school-based deworming (SBD) programs. This guideline proposed that for surveys, a few schools near irrigated areas should be selected and in each school fifty children from the three upper classes should be selected and asked to provide single stool sample.

In line with this guideline, three schools in the study area (Mianya, Mukou and Mbui Njeru primary schools) were purposively selected based on previous studies showing prevalence of *S. mansoni* and STH (Kihara *et al.*, 2007; Masaku *et al.*, 2015). In each school, simple random sampling was carried out to select 60 children aged 8 to 14 years, in classes 2 to 6. Therefore, the total size was 180 school children. This study included children of this age group because recent studies have showed that intestinal parasites occur mainly in children among this age group (Masaku *et al*., 2015). All the selected children provided single stool samples and participated in both the school and household components of the study.

3.5 Field Activities

The school component of the study was carried out between morning and mid-morning hours and the household component was done between late afternoon and evening on the same day (15:30 to 18:00 hours). Data collection using piloted questionnaires was carried out with the help of two trained field assistants' familiar with the study area (Appendix II, IV and V). The field assistants were also responsible for following up the school children to their homes after school.

The research team visited each school prior to the survey and participants were selected using generated random numbers. Parents or guardians of the selected children were invited to a meeting to communicate the study purpose and obtain their consent. All parents/guardians present consented to allow their children to participate in the study and a written informed consent was obtained from them before conducting the study (Appendix I). In addition, assent was sought (verbal) from participating children who were above 13 years (Appendix II).

Each participating child was left with a small plastic container (poly pot) and instructed to collect a morning stool sample on the day of the survey. On the day of the survey, the plastic containers containing morning stool samples were collected from each child. Upon receipt of the stool sample, each of the stool container was labelled with the participant's unique identification number. The samples were kept in a cooler box and transported to Kimbimbi Sub-County hospital laboratory for microscopic screening within the same day. Thereafter, each child responded to an interviewer administered questionnaire on WASH which had been pretested at a local school in Mwea and was adapted before administration.

3.6 Data Collection Tools

A questionnaire was developed to obtain information on children's demographic data, hygiene habits, eating and playing habits, handwashing behavior at critical times and use of water and sanitation facilities. Direct observations on water sources and sanitation facilities were carried out at the school compound and at the homes of the children. Water sources and sanitation facilities were defined using the Joint Monitoring Programme (JMP) guidelines of WHO and United Nations Children Fund (UNICEF) for water and sanitation (WHO/UNICEF, 2016). Improved sanitation facilities were defined as availability of flush toilet, toilet connected to a piped sewer system, toilet connected to a septic system, flush to a pit latrine, ventilated improved pit latrine (VIP), pit latrine with slab and composting toilet. Improved water sources were defined as availability of piped water into dwelling, piped water into yard/plot, public tap or stand pipe, borehole, protected well or spring, bottled water and rain water. The condition of the toilets (cleanliness) was also observed as well as presence handwashing facilities and anal cleansing material in the toilets.

3.7 Laboratory Procedures

The specimens were checked for identification number, quantity and quality (no urine or dirt) and divided into two aliquots. One aliquot was used for microscopic screening of *S. mansoni* and STH infections using double slide Kato-Katz technique while the other was used to screen for protozoan infection using direct saline and iodine wet mount methods. Quality of reagents and instruments were checked by laboratory technicians.

3.7.1 Helminths Screening

Each stool specimen was analyzed for *S. mansoni* and STH infections using the double slide Kato-Katz thick smears method (Katz *et al*., 2006). Briefly, stool sample was passed through a metal sieve to remove fibrous material. Using a spatula, some amount of stool was collected and filled in a template on a slide. Cellophane soaked in glycerine malachite green was placed on the smear and the slide turned upside down, pressed and allowed to spread evenly. After a clearance time of 30 minutes, the slide was examined under a light microscope (100x magnification). Identification of STHs species has been shown in Figure 3.2. Egg counts per slide was multiplied by a factor of 24 to obtain eggs per gram of feces (epg) (Montresor *et al*., 1998).

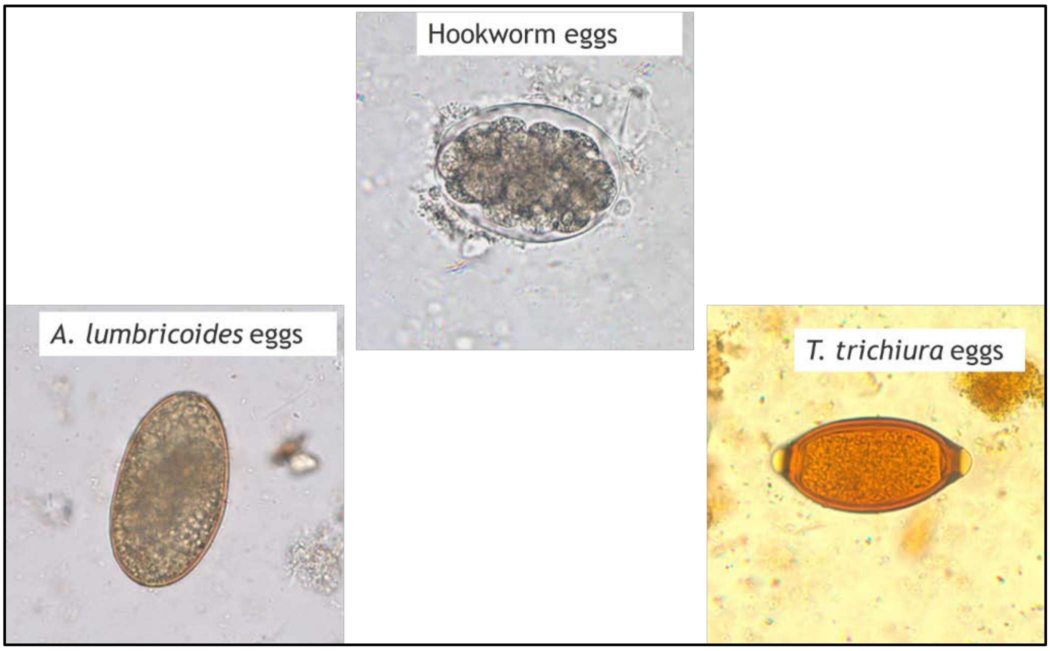


Figure 3.2: Identification of STH Eggs by Microscopy

3.7.2 Protozoa Screening

For each sample, two wet preparations were made for saline wet mount and iodine wet mount tests (Acharya, 2015; Khanna *et al*., 2014). For each of the preparations, approximately 2 grams of stool sample was picked up using a wooden stick and placed on two separate glass slides. The first preparation was mixed with a drop of normal saline (0.9%) and the second with a drop of dilute Lugol's iodine and normal saline (1:5 distilled water). Both slides were covered with a cover slip and observed under the microscope at 10x and at 40x magnification. Saline preparation and iodine allowed for visualization of motile trophozoites and cysts, respectively. Identification of cysts and trophozoites has been shown in Figure 3.3.

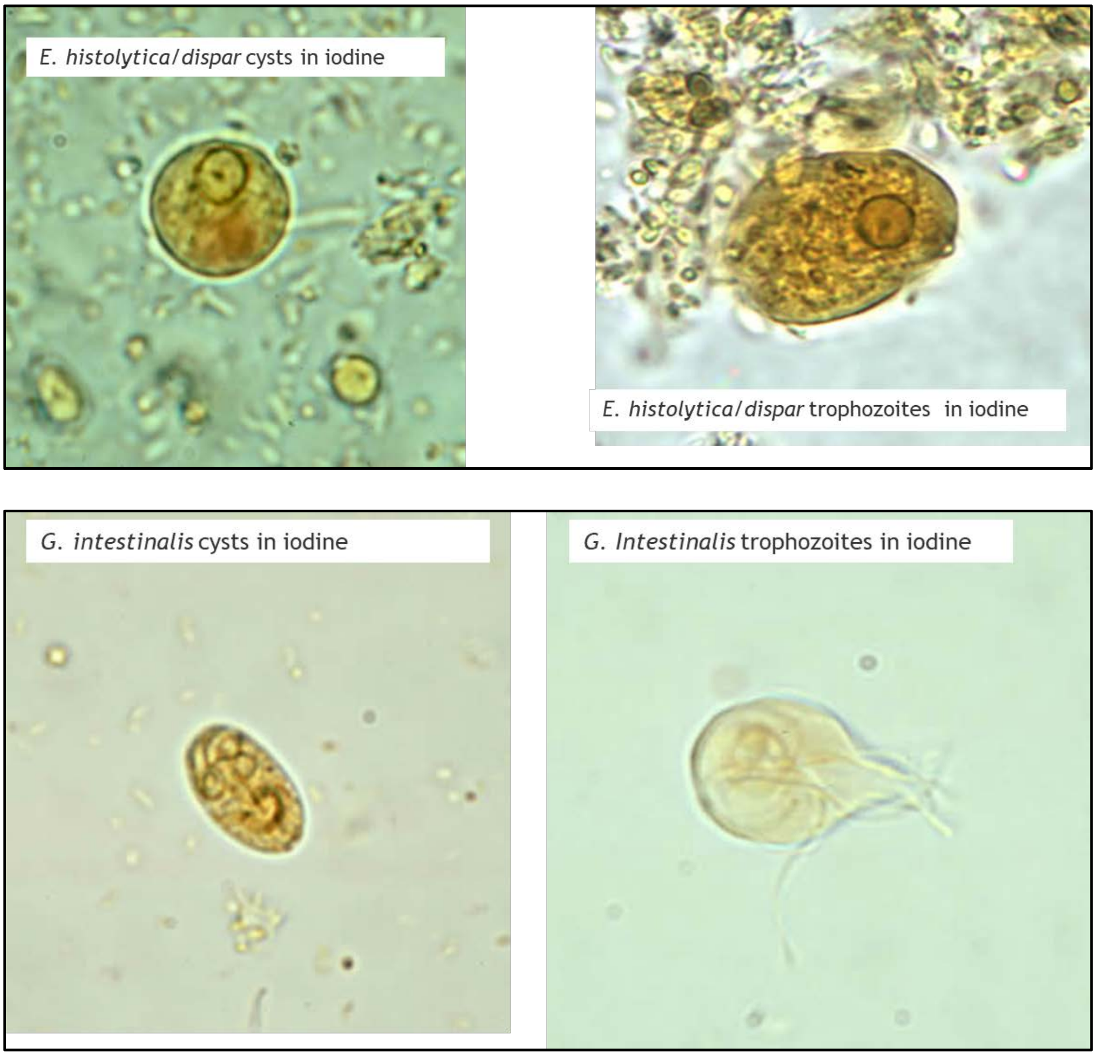


Figure 3.3: Identification of Protozoan Parasites

3.8 Field Testing of Tools

This was done at Ngurubaini Primary school in Mwea town to test reliability and consistency of the study tools (questionnaire, checklists), reagents and equipment. Fifteen study participants from standard 3 were randomly selected to participate in the study upon consent of the parent/guardian. Stool samples were collected and tested for STH's, *S. mansoni* and intestinal protozoa (*G. intestinalis*, *E. histolytica* and others) at the Kimbimbi hospital laboratory. WASH data was collected at home and school of the school children.

3.9 Quality Control

Quality of reagents and instruments were checked by laboratory technicians. This included reagents like iodine, malachite green dyes, microscopes. This was conducted during the pilot stage of the study. At the end of the study, blinded sampling was done by an experienced laboratory technologist to verify the consistency of the microscopic readings.

3.10 Data Management and Statistical Analysis

Sociodemographic information and WASH data were collected using questionnaires. Data was then entered into Excel and imported into STATA version 14.1 for data management and analysis. Univariable analysis was performed for each variable and summarized to give proportions and means. Association between each independent variable and the dependent variable (prevalence of infection) was obtained using binomial logistic regression to give crudes odds ratio and significance of association tested at $p<0.05$. All the variables that showed significance ($p<0.05$) were selected and included in a multivariable model in a sequential block wise manner. Adjusted odds ratio was obtained from the multivariable model and significance set at $p<0.05$.

3.11 Ethical Considerations

The proposal and appropriate certification (CITI) were presented for scientific review to the Eastern and Southern Africa Centre of Parasitic Infections Control (ESACIPAC) Scientific Steering Committee (CSC) and KEMRI Scientific Ethics and Review Unit (SERU) and ethical approval to conduct the study was obtained. The county health and education authorities were sought to obtain permission to undertake the study. The purpose of the study was explained to parents/guardians of the study participants. A written informed consent was obtained from each parent who volunteered his/her child’s participation in the study. Questionnaires were administered to the pupils by the research assistant and the parent/guardian was present during the household survey. The research assistants were trained on ensuring data privacy. A unique ID number was allocated to each child and used on their questionnaires and stool container to ensure their anonymity. The data generated was used for the purpose explained by the principal investigator. All data collected was handled with confidentiality. The school children who tested positive for intestinal parasitic infections were treated with the standard regimen; For STH infections a single 400 mg oral dose of albendazole, additionally a single oral dose of praziquantel (40 mg/kg) for those diagnosed with *S. mansoni*. For participants identified with intestinal protozoa infections, a five-day course of metronidazole (flagyl) was administered for both asymptomatic and symptomatic infections. All the drugs were administered by a registered nurse.

CHAPTER FOUR

RESULTS

4.1 Response Rate

Out of the 180 participants sampled, 100% of them responded to the questionnaire and provided stool samples for laboratory analysis.

4.2 Socio-Demographic Characteristics

The mean age of children was 10.0 years (range: 7-15 years, standard deviation (SD)= 1.6 years). Majority of the study participants were in the age group 10-12 years (99 participants;55%), followed by those below 10 years (66 participants;37%) and those above 12 years (15 participants; 8%) as shown in Table 4.1.

Table 4.1: Socio-Demographic Characteristics of Study Participants

Characteristics	Frequency (n)	%
School		
Mianya	60	33.3%
Mbui Njeru	60	33.3%
Mukou	60	33.3%
Age group		
<10years	66	36.7%
10-12years	99	55.0%
>12years	15	8.3%
Sex		
Female	90	50.0%
Male	90	50.0%

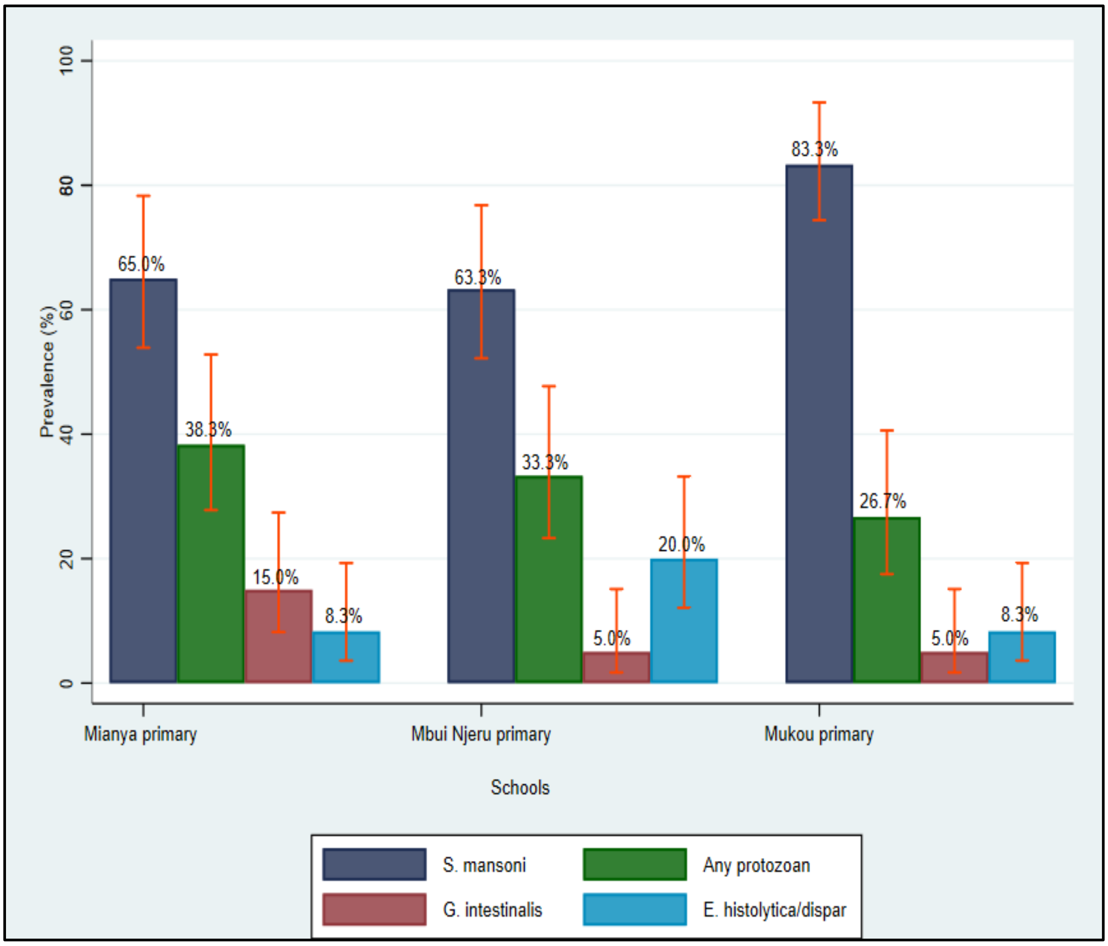


Figure 4.1: Prevalence of Intestinal Parasitic Infections in School Children per Schools

4.3 Description of WASH Factors in the Households and Schools

Data on household and school characteristics and hygiene behaviour of the school children obtained is summarized in this section (Table 4.2). Briefly, thirty-five percent (35.6%) of the households utilized improved sources of water for drinking and domestic purposes while 64.4% utilized unimproved water sources. Ninety-eight percent (98.9%) of the households had a sanitation facility (toilet/latrine). A total of 58 households (32.6%) had wiping material available either toilet paper or other paper in the latrine facilities. Toilet handwashing set-ups were present in 53.1% of the households. Mianya primary school had a population of 453 pupils (219 girls and 234 boys), Mbui Njeru had 604 pupils (301 girls and 303 boys) and Mukou had 641 pupils (325 girls and 316 boys). All the schools drinking water was from improved sources (piped water and harvested rainwater). For personal and environmental hygiene purposes such as handwashing and cleaning classrooms, Mianya and Mbui Njeru used water from unimproved sources (surface water) while Mukou used piped water (improved sources). All the schools had improved gender specific latrine facilities on the school compound. The toilet to pupil ratio for girls in Mianya, Mbui Njeru and Mukou was 22:1, 50:1 and 18:1 respectively. For the boys, toilet to pupil ratio was 26:1, 101:1 and 18:1 respectively. There was no wiping material available in all the toilets. Only Mukou had a handwashing set-up (water from a leaky tin) while Mbui Njeru and Mianya schools had none. The toilets in Mianya and Mukou had a damaged superstructure, four toilet doors did not close and only eight had doors respectively. Mbui Njeru had an intact superstructure with no damage to doors, walls and roofs. Fecal matter in the toilet pit was visible in toilets of Mbui Njeru and Mukou primary and in all schools none of the toilets were adequately cleaned.

Table 4.2: Description of WASH Factors in the Study

	N = 180	100%
Characteristics	**Frequency (n)**	**%**
Open defecation behaviour	90	50.8%
Use of wiping material	63	70.8%
Contact with water bodies	160	88.9%
Eating unwashed food/fruits	46	25.6%
Handwashing after defecation at home	163	90.6%
Handwashing before eating at home	161	89.4%
Wearing shoes behaviour at home	162	90.5%
Presence of wiping material in the latrine	57	31.7%
Type of wiping material		
Toilet paper	13	24.6%
Leaves	13	24.6%
Newspaper	29	50.9%
Presence of a toilet handwashing station	163	90.6%
Damaged toilet structure	32	17.8%
Clean latrines	137	76.1%
Improved sources of water	65	36.1%
Taken deworming medication	133	73.9%
Handwashing after defecation at school	155	86.6%
Handwashing before eating at school	159	88.3%
Wearing shoes behavior at school	158	88.3%

4.4 Prevalence of Infections

Only one case of STH (*A. lumbricoides*) was identified. The overall prevalence of *S. mansoni* was 70.5% (95%CI: 59.0% - 84.2%). The mean infection intensity was 376.2 epg (95%CI: 222.3-530.1) and was categorized as moderate infection. Majority of the infections were light infections 46(25.6%), followed by moderate infections 41 (22.8%) and severe infections 40 (22.2%). (Table 4.3). The overall prevalence of protozoan infections was 32.7% (95%CI: 26.7 - 40.1) as shown the table below.

Table 4.3: Prevalence of Specific Intestinal Parasites

	S. mansoni	Any intestinal protozoan	*G. intestinalis*	*E. histolytica/dispar*	*E. coli*
	n/N (%)	**n/N (%)**	**n/N (%)**	**n/N (%)**	**n/N (%)**
Overall prevalence (N=180)	127(70.5%)	59 (32.7%)	15(8.3%)	22(12.2%)	34(18.9%)
Prevalence by age					
<10years	65.10%	30.30%	5(7.6%)	7(10.6%)	12(18.2%)
10-12years	71.70%	34.30%	10(10.1%)	14(14.1%)	19(19.2%)
>12years	86.60%	33.30%	0	1(6.7%)	3(20.0%)
Prevalence by sex					
Male	73.30%	32.20%	7(7.8%)	9(10.0%)	16(17.8%)
Female	67.70%	33.30%	8(8.9%)	13(14.4%)	18(20.0%)
Prevalence by school					
Mianya	65.00%	38.30%	9(15.0%)	5(8.3%)	11(18.3%)
Mbui Njeru	63.30%	33.30%	3(5.0%)	12(20.0%)	11(18.3%)
Mukou	83.30%	26.60%	3(5.0%)	5(8.3%)	12(20.0%)

4.5 Bivariable Analysis of Risk Factors

Pupils at Mukou primary school had greater odds of *S. mansoni* infections as compared to Mianya pupils (OR=2.69(95%CI:1.14-6.37) p=0.024. Based on age categories, children aged above 12 years had 3.48 times greater odds of *S.mansoni* infection than children aged below 10 years (3.48(95%CI: 1.60-7.55) p=0.002). Among the WASH variables, notable association with *S. mansoni* infection was pupils who handwashed after defecation at home were significantly less likely to be infected as compared to those that did not handwash (0.48(95%CI:0.31-0.75), p=0.001 (Table 4.4).

Table 4.4: Bivariable Analysis of Factors Associated with *S. mansoni* and Intestinal Protozoa Infections

Variables	n (%) N = 180	Bivariable analysis [cOR, (95%CI) p-value]	
		S. mansoni **(n=127)**	**Any protozoan (n=59)**
School			
Mianya	60 (33.3%)	**Reference**	
Mbui Njeru	60 (33.3%)	0.94(95%CI:0.44-1.96) p=0.849	0.80(95%CI:0.89-4.18) **p=0.001***
Mukou	60 (33.3%)	2.69(95%CI:1.14-6.37) **p=0.024***	0.58(95%CI:0.52-2.18) **p=0.001***
Age group			
<10years	66 (36.7%)	**Reference**	
10-12years	99 (55.0%)	1.36(95%CI: 0.69-2.64) p=0.634	1.20(95%CI:0.39-3.68) p=0.746
>12years	15 (8.3%)	3.48(95%CI: 1.60-7.55) **p=0.002***	1.15(95%CI:0.32-4.18) p=0.832
Sex			
Female	90(50.0%)	**Reference**	
Male	90(50.0%)	1.31(95%CI:0.41-2.49) p=0.414	0.95(95%CI:0.62-1.48) p=0.817
Individual and household characteristics			
Open defecation behaviour	90(50.8%)	1.17(95%CI:0.61-1.96) p=0.410	0.66(95%CI:0.32-2.18) p=0.227
Use of wiping material	63(70.8%)	1.56(95%CI:0.44-6.62) p=0.550	0.64(95%CI:0.42-4.18) **p=0.001***
Contact with water bodies	160(88.9%)	0.78(95%CI:0.44-1.96) p=0.659	0.70(95%CI:0.62-1.18) **p=0.001***
Eating unwashed food/fruits	46(25.6%)	1.25(95%CI:0.59-2.60) p=0.563	1.12(95%CI:0.32-5.18 p= 0.673
Handwashing after defecation at home	163(90.6%)	0.48(95%CI:0.31-0.75), **p=0.001***	0.51(95%CI:0.26-2.78) p=0.349
Handwashing before eating at home	161(89.4%)	1.12(95%CI:0.92-1.35) p=0.234	0.82(95%CI:0.62-3.95) p=0.178
Wearing shoes behavior at home	162(90.5%)	1.76(95%CI: 1.20-2.99) p=0.036	0.89(95%CI:0.46-1.78) p=0.745
Presence of wiping material in the latrine	57(31.7%)	0.86,(95%CI:0.53-1.39) p=0.543	0.92(95%CI:0.48-1.76) p=0.808

Variables	n (%) N = 180	Bivariable analysis [cOR, (95%CI) p-value]	
		***S. mansoni* (n=127)**	**Any protozoan (n=59)**
Type of wiping material			
Leaves	13(24.6%)	**Reference**	
Toilet paper	13(24.6%)	0.37(95%CI:0.19-0.70**)** **p=0.002***	-
Newspaper	29(50.9%)	0.70(95%CI:0.53-1.39) p=0.050	0.85(95%CI:0.36-2.99) p=0.708
Presence of a toilet handwashing station	163(90.6%)	1.42(95%CI:0.78-2.60) p=0.256	0.78(95%CI:0.62-6.18) **p=0.034***
Damaged toilet structure	32(17.8%)	1.61(95%CI:0.53-5.18) p=0.418	2.63(95%CI:2.13-4.16) p=0.412
Clean latrines	137(76.1%)	1.21(95%CI:0.49-2.96) p=0.672	0.84(95%CI:1.02-3.29) **p=0.040***
Improved sources of water	65(36.1%)	1.45(95%CI:0.75-2.80) p=0.265	1.08(95%CI:0.38-1.48) p=0.584
Taken deworming medication	133(73.9%)	1.74(95%CI:0.91-3.39) p=0.094	0.81(95%CI:0.23-2.78) p=0.745
Handwashing after defecation at school	155(86.6%)	1.22(95%CI:1.15-2.39) **p=0.001***	0.98(95%CI:0.08-11.72) p=0.988
Handwashing before eating at school	159(88.3%)	0.95(95%CI:0.53-1.39) p=0.870	0.97(95%CI:0.32-2.94) p=0.960
Wearing shoes behavior at school	158(88.3%)	0.94(95%CI:0.46-1.93) p=0.876	0.32(95%CI:0.08-1.31) p=0.113

***significant association p<0.05, - variable omitted because of insufficient observations**

4.6 Multivariable Analysis of Risk Factors

After adjusting for other factors, pupils from Mianya primary were 1.23 times more likely to be infected with *S. mansoni* compared to Mukou primary, children aged above 12 years had 3.19 times greater odds of *S. mansoni* infection compared to those below 10 years and handwashing after defecation was protective against *S. mansoni* infection (aOR=0.39(95%CI:0.25-0.59) p=0.001) (Table 4.5).

Table 4.5: Multivariable Analysis of Risk Factors of *S. mansoni* and Any Intestinal protozoa infection

Variables	Multivariable analysis [aOR(95%CI) p-value]	
	S. mansoni	**Any protozoan**
	(n=127)	**(n=59)**
School		
Mbui Njeru	0.81(95%CI: 0.76-0.87) p=0.001	3.69(95%CI:3.28-4.35) p=0.001*
Mianya	1.23(95%CI:1.14-1.32) p=0.001	1.81(95%CI:1.36-2.41) p=0.001*
Mukou	**Reference**	**Reference**
Age group		
<10 years	**Reference**	
10-12 years	1.37(95%CI:0.35-5.38) p=0.649	
> 12 years	3.19(95%CI:1.25-8.14) **p=0.015***	
Gender		
Female	**Reference**	
Male	1.29(95%CI:0.66-2.53) p=0.455	2.41(95%CI:1.80-3.22) **p=0.010***
Individual and household characteristics		
Use of anal wiping material	-	0.55(95%CI:0.33-0.91**)** **p=0.019***
Handwashing after defecation at home	0.39(95%CI:0.25-0.59) p=0.001*	-
Water contact	-	0.32(95%CI:0.27-0.37) p=0.550
Wearing shoes behavior at home	1.67(95%CI:1.12-2.46**)** **p=0.010***	-

***significant association p<0.05, - variable omitted because of insufficient observations**

CHAPTER FIVE

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 Discussion

5.1.1 Prevalence of Intestinal Parasitic Infections

A total of 127 out of 180 school children (70.6%) were infected with *S. mansoni* and infections categorized as light infections. Mwea region (East and West) is home to the massive Mwea irrigation scheme thar is served by numerous water canals supplying irrigation water to farms and neighbouring villages (Gichuki *et al*., 2019). These water canals are known to harbour snails that are vectors of the Schistosoma parasite (Kihara *et al*., 2007) The prevalence of 70% was high as compared to findings from other studies conducted in the study area, prevalence of 50.6% was recorded by (Masaku *et al*., 2015) and 47.0% recorded by (Kihara *et al*., 2007) . This may be due to interruption of school based deworming activities in the study area owing to the teacher strikes during that year and inconsistent MDA to school children. Among the three schools, Mukou had the highest prevalence (83.3%) followed by Mianya primary (65.0%) and Mbui Njeru (63.3%). This highest prevalence observed in Mukou compared to the other two schools is expected given its close proximity to the River Thiba

The study observed that children aged above 12 years had a higher prevalence of 86.6% compared to those aged 10 to 12 years and those below 10 years. Infections with *S. mansoni* are usually higher among the older school children as compared to their counterparts(World Bank & Global Partnership for Education, 2010) . Similar findings have been observed in Western Kenya, where prevalence of *S. mansoni* was higher in school children aged between 10-12 years compared to than those aged ≤ 10 years; 16.3% (Handzel *et al*., 2003). This higher prevalence observed in the age cohort is consistent with the existing knowledge that school age children (5-14 years) are the most affected by the infection. In Ethiopia, prevalence of *S. mansoni* in children aged between 6 – 14 years was reported as 12.6% and males had a significantly higher rate than females (Tulu *et al*., 2014). Our findings also observed a higher prevalence of *S. mansoni* infection among the male gender compared to the females; 73.3% and 67.7%

respectively. The higher prevalence of *S. mansoni* among the older school children may be due to their playing habits which led to increased contact with water infected with *S. mansoni* (WHO, 2002). And arguably, male children in this age group tend to be more adventurous and playful than females therefore increasing their water contact as compared to females (Masaku *et al*., 2015).

The overall prevalence of intestinal protozoa was 32.7%. A study done in rural schools in Thika district observed a similar prevalence of 38.9% (Ngonjo *et al*., 2012). Study findings revealed that, prevalence of intestinal protozoa was significantly higher in males as compared to females. Similar findings were observed in a study among primary children in Ethiopia (Tulu *et al*., 2014). Although the reason for this association is not known, it may be attributed to the adventurous nature of male children while outdoors (similar to higher *S. mansoni* infection). Prevalence of intestinal protozoa was higher in school children aged 12-13 years (36.1%), followed by 10-11 years (33.3%) and 8-9 years (30.8%).

Prevalence studies have observed poly-parasitism (co-infection) among school children in areas endemic for intestinal parasitic infections. This is a common occurrence given the similar modes of transmission across the parasites (fecal oral route). In our study, the overall prevalence of co-infection with *S. mansoni* and any protozoa infection was 22.8%. This was also observed in studies conducted among primary school children in Thika district where prevalence of *S. mansoni* and other STHs was 13.8% (Ngonjo *et al*., 2012). Another study conducted in Eastern parts of Kenya showed prevalence of co-infection with intestinal protozoa and STHs was 7.1% (Kamande *et al*., 2015). Similarly, in Ethiopia, polyparasitism with STHs and *S. mansoni* among school children was found in 515 (56.7%) of the total examined (Mengistu *et al*., 2007)

5.1.2 Household and School WASH Characteristics Associated with Intestinal Parasitic Infections

Sanitation facilities interrupt the transmission of feacal–oral disease at its most important source by preventing human fecal contamination of water and soil. Epidemiological evidence reveal that sanitation is at least as effective in preventing disease as improved water supply (Abossie & Seid, 2014). Eighty-four (84.7) percent of households and all schools used improved sanitation facilities. The use of improved sanitation facilities is associated with lower odds of intestinal parasitic infections (Freeman *et al*., 2015). Therefore, the use of unimproved sanitation facilities in 15.3% of the households may increase risk of infections as compared to households utilizing improved sources. All the schools utilized drinking water from improved sources (piped water and harvested rainwater) while only 35.6% of the households utilized such sources. The use of unimproved drinking water sources was recorded in 64.4% of households. These sources included surface water and unprotected wells. In a Malaysian study, children who used unsafe drinking water sources had 2.2 times the odds of having an STH infection compared to those using piped water for drinking (Nasr *et al*., 2013). This agreed with (Freeman *et al*., 2015) findings where the use of improved water sources for drinking was associated with significantly lower odds of STH infection. A similar trend was observed in the current study; of those positive for *S. mansoni* infection, 45.6% utilized unimproved water sources for drinking while 25.0% utilized improved sources. Thus, in our study, children from 64.4% households had increased odds of having intestinal parasitic infections.

The toilet to pupil ratio for girls in Mianya, Mbui Njeru and Mukou was 22:1, 50:1 and 18:1 respectively. For the boys, toilet to pupil ratio was 26:1, 101:1 and 18:1 respectively. Out of the three schools, Mianya and Mukou primary schools met the required toilet to pupil ratio for both girls and boys. According to the Kenyan government, the recommended toilet to pupil ratio is 25:1 and 30:1 for girls and boys respectively (Ministry of Education, 2008). It is hypothesized that decreasing the toilet to pupil ratio increases toilet usage in the school and reduces open defecation (Garn *et al*., 2014). These findings are supported by (Freeman *et al*., 2015) that found students attending schools with higher pupil to latrine ratios had significantly higher rates of infection intensity. Since Mbui Njeru had the highest toilet to pupil ratio, pupils there may have an increased risk infection.

Out of the three schools, only Mbui Njeru had latrines in good structural condition, Mianya and Mukou primary had doors that did not close. Of the households, 83.2% had latrines in good structural condition. Presence of latrines with good structural integrity (functional doors, intact walls, slabs and roofs) are associated with significantly lower odds of *A. lumbricoides* infection and lower rates of infection intensity (Freeman *et al*., 2015). The structural conditions of the latrine was associated with the toilet usage (Freeman *et al*., 2015). Therefore, the conditions of the toilet in the schools (Mianya and Mukuo) and some households may increase the risk of infection with intestinal parasites.

Of the households, 32.6% had wiping material present in the toilets. Anal cleansing materials, such as toilet paper, are almost never provided by Kenyan primary schools(Greene *et al*., 2012). These findings are agree with those observed in the current study, where wiping material was absent in all school toilets. The lack of toilet paper at schools have been shown to be associated with diarrhea. According to (Freeman *et al*., 2015) access to tissue/water for anal cleansing yielded lower odds of having any STH infection. Therefore, the lack of wiping material in the school and majority of the household toilets increases the risk of infection with STH. Lack of resources (soap and water), inadequate sanitation facilities and location of hand washing stations are drivers for children not practising proper hygiene behavior (Dube & January, 2012). Presence of toilet handwashing setups was observed in 53.1% of households and in Mukou primary school. Pupils in schools that have hand-washing facilities equipped with soap and water have lower odds of being infected with STH infections *et al*. However, handwashing setups that have soap are rare in Kenyan schools and rural homes. In the current study, all the handwashing setups only had water present. Toilet handwashing set ups in the homes increase the risk of IPI as demonstrated by (World Bank, 2009).

Attitudes, knowledge, and beliefs are directly linked to hygiene behavior. Having poor knowledge, practice and attitudes to personal hygiene have negative consequences for a child's long term hygiene behavior (Assefa & Kumie, 2014). Handwashing behavior during critical times (after defecation and before eating) at the school and household environment was similar according to the findings. After defecation, handwashing behavior was reported as 90.6% and 86.1% at home and school respectively. Handwashing before eating was 89.4% and 88.9% at home and school respectively. These findings are higher than those observed in an Ethiopian study where handwashing at critical times as reported at less than 30% (Assefa & Kumie, 2014). This may be due to a limited knowledge on handwashing reported in the Ethiopian study. Open defecation behavior at home was reported at 49.4%. This behaviour is considered an important risk factor for STH infection as depicted by (Kattula *et al*., 2014). However, this was not supported by the findings of the current study. Open defecation was not reported in the school. Therefore, the home environment may be an important transmission site through the route of open defecation.

5.1.3 WASH Characteristics Associated with S. mansoni and Intestinal Protozoa Infections

Behavioural and hygiene characteristics have been associated with STH infections. Studies done in Côte d'Ivoire, South India and Ethiopia have found significant associations between hygiene behavior and presence of infection (Gelaw *et al*., 2013; Kattula *et al*., 2014; Schmidlin *et al*., 2013). . This hygiene behaviour includes handwashing at critical times, wearing shoes when outside, use of wiping material. In this study, hygiene characteristics (handwashing after defecation and use of wiping material), respectively had odds of below one for *S. mansoni* infection and intestinal protozoa infection, hence protective factors both infections. Exposure to infected water is known to be significantly associated with *S. mansoni* infection as demonstrated in a study done in Western Kenya (Handzel *et al*., 2003).. Activities such laundry, bathing and recreational activities cause exposure to infected water and are therefore associated with infection (Grimes *et al*., 2015). This association was not established in the current study. Although association was not significant, of those positive for *S. mansoni* infection 52.8% were exposed through domestic purposes while 17.8% had no such contact ($p>0.05$). With regards to recreational activities, 42.8% of those positive swam in surface water while 27.8% did not swim ($p>0.05$).

Access to wiping material for anal cleansing is a protective factor against infections. This association was observed in a study conducted in Kenyan school children where frequent availability of tissue/water for anal cleansing led to significantly lower rates of infection intensity and it emerged as the most important predictor of STH infection (Freeman *et al*., 2015).. Study findings also showed significant lower odds of intestinal protozoa infections among school children who used anal cleansing material. Similar findings were observed in a Turkish study where not using any anal wiping material has been significantly associated with intestinal protozoa infection (Okyay *et al*., 2004).

Access to safe drinking water sources and latrine facilities has been associated with lower prevalence of intestinal parasites. A study in Southern Ethiopia, showed that primary school children who had access to safe drinking water sources and latrine facilities had a lower prevalence of intestinal protozoa (Abossie & Seid, 2014). These findings were consistent with those of the current study. In the Ethiopia study, overall prevalence of intestinal protozoa was 23.5%; access to safe drinking water and latrine facilities was reported at 94% and 94.25% respectively. In the current study, the overall prevalence of intestinal protozoa was 32.8%; access to safe drinking water and latrine facilities was reported at 35.6% and 98.9% respectively. Compared to the Southern Ethiopian study, the lower use of safe drinking water sources among our study participants may be a contributing factor to the observed higher prevalence of intestinal protozoa.

5.2 Conclusion

Infections with *S. mansoni*, intestinal protozoa as well as their coinfection are a public health problem in school children in Mwea irrigation scheme. The overall prevalence of *S. mansoni* was 70.5% while that of protozoan infections was 32.7%.

Majority of households (65%) were using unimproved sources of water for drinking which are considered unsafe while most homes used improved sanitation facilities. In the schools, use of unimproved water sources exposed the pupils to potential infections with *S. mansoni* and intestinal protozoa. In the school, sanitation facilities (latrines) did not meet the Kenyan recommendation of the toilet to pupil ratio.

Contact with water due to proximity to the river was associated with infections observed in Mianya primary school.The handwashing after defecation at home was associated with *S. mansoni* infections while use of wiping material associated with protozoan infection. Therefore, the study suggests mixed impacts of household and school WASH on prevalence of infection. This agrees with findings of the Kenyan study conducted among school children (Freeman *et al*., 2015).

5.3 Recommendations

1. MOH in conjunction with County government should establish feasible approaches for sustaining deworming for *S. mansoni* infections and treatment for intestinal protozoa infections
2. County governments should employ friendly approaches within communities and schools to improve water sources, sanitation, and handwashing behaviour both at homes and schools. This should also include provision of other commodities like toilet paper.
3. Ministry of Health, Education and county governments should codevelop strategies that combine health education, deworming efforts and improved WASH to combat parasitic infections

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APPENDICES

Appendix I: Written Informed Consent

Title: Prevalence of intestinal parasitic infections and associated water, sanitation and hygiene factors among children in schools in Mwea west, Kirinyaga County, Kenya

Investigators: E. Njambi, D. Magu, J. Masaku, S. Njenga

Introduction

The purpose of this consent form is to inform you about the study, so that you can decide if you will allow your child to participate or not. Please read this form carefully. You may ask questions about what we will ask your child to do, the risks, the benefits, their rights as a volunteer, or anything else about the research or this form that is not clear. If you allow him/her to participate in the research study, you will be asked to sign this consent form. We will give you a copy of this form for your records.

Purpose of the research

This study aims to determine the prevalence of intestinal parasitic infections among school children aged 8-14 years from schools in Mwea, Kirinyaga, to establish the WASH characteristics at home and school associated with occurrence of IPI and relate the water, sanitation and hygiene practices associated with infectivity of IPI at home to school environment.

Study procedures

The study will involve a school and home based survey where observations will be made on water and sanitation conditions of the schools and homes of the study participants (school children). In addition, the study participants will respond to a questionnaire on their hygiene practices and will fill a small container with stool sample that will be used to screen for IPI (soil transmitted helminths and intestinal protozoa).

Benefits

This study will give information on the WASH factors associated with intestinal infections. This will be used to develop interventions for prevention and control of intestinal parasitic infection. The study participants will also be treated in case they are infected with parasites therefore improving their physical health.

Risks

This is a study that involves minimal risk because the data and specimen collected from the school children is not sensitive and will be done in a non-invasive manner. The deworming drugs administered may cause the participant some discomfort however this is only for a short time and very mild.

Confidentiality

Any information your child gives us during this study will be kept private. His/her name will not be used in any report coming from this study nor on any forms used in this study apart from this consent form. A special ID number will be used on all study forms. The link between his/her name and ID number will be stored in a locked box to avoid loss. Consent forms will be stored in separate locked files as will information you give us about ways to contact you. Only study staff will be allowed to see the files.

Problems or questions

If you have questions or comments about the study, you can contact the Principal Investigator (Elizabeth Njambi) at the following telephone number 0721 414269. Alternatively, you can contact the Scientific, Ethics and Research Unit, KEMRI P.O. Box 54840-00200, Nairobi at the following numbers: 020 2722541, 0722 205901, 0733 400003.

Right to refuse/withdraw

Your child's participation in this study is your choice. You can choose not to let him/her answer any questions or give his/her stool samples. You can choose to withdraw your child from the study at any time for any reason.

Statement of consent and signatures

I have read this form or had it read to me. I understand that my decision whether or not to allow my child to take part in the study is voluntary. I understand that I may withdraw him/her at any time. My signature below confirms that I freely agree him/her to join this study.

______________________________ ________________________ ______________

Name of Parent/ Signature Date

Guardian of Participant

______________________________ ________________________ ______________

Elizabeth Kimiri – JKUAT Signature Date

Appendix II: Assent Form for Children Aged 13–14 Years

Title: Prevalence of intestinal parasitic infections and associated water, sanitation and hygiene factors among children in schools in Mwea west, Kirinyaga County, Kenya

Investigators: E. Njambi, D. Magu, J. Masaku, S. Njenga

Prevalence of intestinal parasitic infection among primary school children and association with water, sanitation and hygiene (WASH) in Mwea West District, Kirinyaga County

You are being asked to take part in this study being carried out by researchers from the Kenya Medical Research Institute (KEMRI). The study will help us understand the proportion of school children infected with worms and their use of water, sanitation facilities and hygiene behaviors. This will help in preventing the children from falling sick because of worms and parasites frequently.

If you agree to take part in this study, we will ask you to give stool samples so that we can check for worms and parasites in your body, answer some questions on your use of water and sanitation facilities as well as your hygiene behavior. If you are found to have any worms in your body, you will be given medication to get rid of these worms and parasites present in your body, free of charge.

You do not have to take part in this study, if you don't want to, but there will be no harm if you participated. If you agree to take part in this study, please sign your name in the space provided:

YES________I agree to take part in this study

______________________________ ______________________ _____________

Name of Child Signature Date

______________________________ ______________________ _____________

Elizabeth Kimiri JKUAT Signature Date

Appendix III: Questionnaire

Title: Prevalence of intestinal parasitic infections and associated water, sanitation and hygiene factors among children in schools in Mwea west, Kirinyaga County, Kenya

Investigators: E. Njambi, D. Magu, J. Masaku, S. Njenga

Date_______________School________________________ID NO: _________________

Water, sanitation facilities and hygiene behaviors of school children in Mwea, Kirinyaga

Instructions

The interviewer will administer this questionnaire to the study participant

Demographic information

1. Age:
2. Sex: Male=1, Female=2
3. Class (Standard 2 - 6):

Environmental variables (water and sanitation facilities)

Is there a toilet/latrine facility in your compound? Yes=0, No=1

4. At home=______________
5. At school=_____________

If yes, where is the toilet facility? Inside/attached to the house=1, elsewhere on compound not more than 100 metres from the house=2, outside compound=3

6. At home = ______________
7. At school = _____________

What kind of toilet facility is in use? Flush = 1, Pit Latrine = 2

8. At home = ____________________

9. At school = ________________________

Is the latrine shared? Yes = 1, No = 0

10. At home = _______________________
11. At school = ______________________

Is there a hand washing station for use near the pit latrine? Yes = 0,   No = 1

12. At Home = ________________

13. At School = ______________________

If yes, what type of station is there? Tap water = 1, leaky tin = 2, water in a jar or basin = 3, water canal = 4,

14. At home=_____________________

15. At school=______________________

What is the main source of water for drinking and at home? Piped/tap water = 0, borehole or well = 1, harvested rainwater in a tank= 2, stream or river = 3, canal = 4.

At Home=_____________

Do you store water for drinking in the household? Yes = 0, No = 1

16. At Home=_______________

If yes, where do you store it? Barrel with tap = 1, jerry can = 2, Tank/drum=3, Open bucket = 4

18. At Home=_____________

Is the water you drink treated in any way to make it safer? Yes = 0,   No = 1

19. At home__________________

20. At school_____________________________

If yes, how is it treated? By boiling = 1, add bleach/chlorine = 2, filtration or straining through a cloth = 3, solar disinfection = 4, sedimentation =5

21. At home_____________
22. At school (ASK TEACHER)________________________

Hygiene behavior

Do you wash your hands with water and detergent (soap or ash) after defecation? Yes always = 0, Yes Sometimes = 1, Water only = 2, Not at all = 3,

23. At home_________________________
24. At school_____________________________

Do you wash your hands with water and detergent (soap or ash) before eating? Yes always = 0, Yes Sometimes = 1, Water only = 2, Not at all = 3,

25. At home______________________
26. At school_____________________________

Do you wear shoes when you are outdoors (at home and school)? Yes always = 0, Yes Sometimes = 1, No = 2

27. At home___________________
28. At school_____________________________

Do you relieve yourself in fields/bushes? Yes always = 2, Yes Sometimes = 1, No = 0

29. At home__________________
30. At school___________________(If NO, Skip to 37)

After relieving yourself, do you use any wiping material? Yes always = 0, Yes Sometimes = 1, No = 2

31. At home__________________
32. At school_________________

What do you use for wiping yourself? Toilet paper = 1, other paper = 2, water = 3, leaves = 4

33. At home__________________
34. At school_________________________

How is the wiping material disposed of? Drop in pit latrine=1, bury it=2, leave it there = 3, river=4.

35. At home__________________
36. At school__________________________

Do you come into contact river/stream/canal water? Yes = 1, No = 0

37. Contact=_____________________

What is the reason for contact? Swimming=1, Playing=2, Fishing=3, Domestic chores=4

38. Reason for contact =_______________

Do you pick up and eat food/fruit once it has already fallen to the ground without washing it? Yes always = 2, Yes sometimes = 1, No = 0

39. Eating habits=________________

Appendix IV: Study Approvals

KENYA MEDICAL RESEARCH INSTITUTE

P.O. Box 54840 - 00200 NAIROBI - Kenya
Tel: (254) (020) 2722541, 254 (020) 2713349, 0722-205901, 0733-400003 Fax (254) (020) 2720030
Email: director@kemri.org info@kemri.org Website:www.kemri.org

KEMRI/RES/7/3/1 **September 10, 2015**

TO: **ELIZABETH NJAMBI KIMIRI,**
PRINCIPAL INVESTIGATOR

THROUGH: **PROF. SAMMY NJENGA,**
THE DIRECTOR, ESACIPAC,
NAIROBI

Forwarded 15-09-2015

Dear Madam,

RE: SERU PROTOCOL NO. KEMRI/SERU/ESACIPAC/008/3093 *(RESUBMISSION)*: PREVALENCE OF INTESTINAL PARASITIC INFECTIONS AMONG PRIMARY SCHOOL CHILDREN AND ASSOCIATION WITH WATER, SANITATION AND HYGIENE (WASH) IN MWEA WEST DISTRICT, KIRINYAGA COUNTY, CENTRAL KENYA *(VERSION 02 DATED 17TH AUGUST 2015)*

Reference is made to your letter dated 17th August, 2015. KEMRI/Scientific and Ethics Review Unit (SERU) acknowledges receipt of the revised study documents on 27th August, 2015.

This is to inform you that the issues raised during the 241st ERC meeting of the KEMRI/Ethics Review committee held on 21st July, 2015 have been adequately addressed. Consequently, the study is granted approval for implementation effective this day, **10th September, 2015** for a period of one year. Please note that authorization to conduct this study will automatically expire on **9th September, 2016.** If you plan to continue data collection or analysis beyond this date, please submit an application for continuation approval to SERU by **July 29, 2016**.

You are required to submit any proposed changes to this study to SERU for review and the changes should not be initiated until written approval from SERU is received. Please note that any unanticipated problems resulting from the implementation of this study should be brought to the attention of SERU and you should advise SERU when the study is completed or discontinued.

You may embark on the study.

Yours faithfully,

FOR: **PROF. ELIZABETH BUKUSI,**
ACTING HEAD,
KEMRI/SCIENTIFIC AND ETHICS REVIEW UNIT

KIRINYAGA COUNTY GOVERNMENT

COUNTY DEPARTMENT OF HEALTH

Telegrams: "MEDICAL", KERUGOYA
Telephone: (060) 21564, 21058
Fax (060) 21564
E- mail: dmohkirinyaga@yahoo.com
When replying please quote:

COUNTY DIRECTOR OF HEALTH
KIRINYAGA,
P. O. BOX 24,
KERUGOYA

1^{ST} OCTOBER 2015

REF; CDH/RES/VOL.I/105

THE MEDICAL SUPERINTENDENT
KIMBIMBI SUB COUNTY HOSPITAL

RE;APPROVAL TO CONDUCT RESEARCH IN KIMIMBIMBI SUB COUNTY HOSPITAL – ELIZABETH NJAMBI KIMIRI.

We acknowledge the application for approval by the above named to conduct a research project titled "Prevalence and intensity of intestinal parasitic infection among school children and association with the water, sanitation and hygiene (WASH)" in Mwea West District, Kirinyaga County, Central Kenya.

This is a course project in the Master of Science Degree in Public Health at Jomo Kenyatta University of Agriculture and Technology – JKUAT, ITROMID.

She is hereby granted approval to conduct this project in Kimbimbi Sub County Hospital for a period of one year.

She is **Expected to Submit** regular research findings to the County Department of Health with a final report being submitted before expiry of the approval period.

She may embark on the study.

COUNTY DIRECTOR
OF HEALTH
P. O. Box 24-10300, KERUGOYA

DR. ESBON GAKUO
COUNTY DIRECTOR OF HEALTH
KIRINYAGA.

CC

- **CHIEF OFFICER;HEALTH**

Appendix V: Journal Publication

Hindawi
Journal of Tropical Medicine
Volume 2020, Article ID 3974156, 9 pages
https://doi.org/10.1155/2020/3974156

Research Article

Prevalence of Intestinal Parasitic Infections and Associated Water, Sanitation, and Hygiene Risk Factors among School Children in Mwea Irrigation Scheme, Kirinyaga County, Kenya

Elizabeth Njambi ,[1] Dennis Magu,[1] Janet Masaku,[2] Collins Okoyo ,[2] and Sammy M. Njenga[2]

[1]*College of Health Sciences (COHES), Jomo Kenyatta University of Agriculture and Technology (JKUAT), P. O. Box 62000–00200, Nairobi, Kenya*
[2]*Eastern and Southern Africa Centre of International Parasite Control (ESACIPAC), Kenya Medical Research Institute (KEMRI), P. O. Box 54840–00200, Nairobi, Kenya*

Correspondence should be addressed to Elizabeth Njambi; enkimiri@gmail.com

Received 14 September 2019; Revised 20 March 2020; Accepted 7 April 2020; Published 11 May 2020

Academic Editor: Pedro P. Chieffi

School children bear a significant burden of intestinal parasitic infections. Because they spend most of their time at home and school, it is necessary to identify the key water, sanitation, and hygiene (WASH) factors associated with these infections in both environments. This was a cross-sectional survey conducted in Mwea West, Kirinyaga County. 180 primary school children aged 8–14 years were randomly selected from three schools (Mianya, Mbui Njeru, and Mukou primary schools). Questionnaires and checklists were administered and single stool samples were collected. Stool samples were microscopically examined for *Schistosoma mansoni*, soil-transmitted helminths, and protozoan infections. Data on WASH were obtained at home and school. The factors significantly associated with *S. mansoni* and intestinal protozoa infections in the school children were determined using univariable and multivariable logistic regression models reporting the odds ratio at 95% confidence intervals. The overall prevalence of *S. mansoni* and intestinal protozoa infections was 70.5% (95% CI: 59.1–84.3) and 32.7% (95% CI: 26.8–40.1), respectively. Only one case of STH (*A. lumbricoides*) was identified. The prevalence of coinfections of *S. mansoni* and intestinal protozoa infections was 22.8% (95% CI: 19.2–27.1). An increased prevalence of *S. mansoni* infection was associated with children above 12 years (aOR = 3.19, p = 0.015), those in Mianya primary (aOR = 1.23, p = 0.001), those in Mukou primary (aOR = 3.19, p = 0.001), and reported behavior of wearing shoes at home (aOR = 1.67, p = 0.010). However, handwashing behavior after defecation at home (aOR = 0.39, p = 0.001) was protective against *S. mansoni* infection. For any protozoan infection, male children had increased odds of infection (aOR = 2.41, p = 0.001) while use of wiping material (aOR = 0.55, p = 0.019) and water contact (aOR = 0.32, p = 0.001) was protective against intestinal protozoa infections. Infections with *S. mansoni* and any protozoa and their coinfection were present. Findings revealed that several hygiene factors were protective against infections while other were risk factors. Therefore, deworming should be complemented with behavior education on hygienic habits.

1. Introduction

Intestinal parasitic infections are a major public health concern in developing countries and the risk factors for infection include living in rural areas, poor communities, poor sanitation, lack of clean water, and poor personal hygiene [1]. In addition to these risk factors, low level of awareness resulting in poor hygiene habits leads to school-aged children suffering the highest infection rates [2, 3]. These infections are caused by soil-transmitted helminths (STH), *Schistosoma mansoni*, and intestinal protozoan parasites among others. STH are commonly caused by infection with *Ascaris lumbricoides* (roundworm), *Ancylostoma duodenale*, *Necator americanus* (hookworm), and

2.5. Household Survey. Using a checklist, direct observations were carried out at each participating child's home to investigate the water sources and sanitation facilities. This was performed with the assistance of the head of household or any adult family member (above 18 years old).

2.6. Data Collection Tools. A questionnaire was developed to obtain information on children's demographic data, hygiene habits, eating and playing habits, handwashing behavior at critical times, and use of water and sanitation facilities. Direct observations on water sources and sanitation facilities were carried out at the school compound and at the homes of the children. Water sources and sanitation facilities were defined using the Joint Monitoring Programme (JMP) guidelines of the WHO and the United Nations Children Fund (UNICEF) for water and sanitation [25]. Improved sanitation facilities were defined as availability of flush toilet, toilet connected to a piped sewer system, toilet connected to a septic system, flush to a pit latrine, ventilated improved pit latrine (VIP), and pit latrine with slab and composting toilet. Improved water sources were defined as availability of piped water into dwelling, piped water into yard/plot, public tap or stand pipe, borehole, protected well or spring, bottled water, and rain water. The condition of the toilets (cleanliness) was also observed as well as presence of handwashing facilities and anal cleansing material in the toilets.

2.7. Laboratory Procedures. The specimens were checked for identification number, quantity, and quality (no urine or dirt) and divided into two aliquots. One aliquot was used for microscopic screening of *S. mansoni* and STH infections using double slide Kato-Katz technique while the other was used to screen for protozoan infection using direct saline and iodine wet mount methods. Quality of reagents and instruments was checked by laboratory technicians.

2.8. Helminths Screening. Each stool specimen was analyzed for *S. mansoni* and STH infections using the double slide Kato-Katz thick smears method [26]. Briefly, the stool sample was passed through a metal sieve to remove fibrous material. Using a spatula, some amount of stool was collected and filled in a template on a slide. Cellophane soaked in glycerine malachite green was placed on the smear and the slide was turned upside down, pressed, and allowed to spread evenly. After a clearance time of 30 minutes, the slide was examined under a light microscope (100x magnification). Egg counts per slide was multiplied by a factor of 24 to obtain eggs per gram of feces (epg) [22].

2.9. Protozoa Screening. For each sample, two wet preparations were made for saline wet mount and iodine wet mount tests [27, 28]. For each of the preparations, approximately 2 grams of stool sample was picked up using a wooden stick and placed on two separate glass slides. The first preparation was mixed with a drop of normal saline (0.9%) and the second with a drop of dilute Lugol's iodine and normal saline (1 : 5 distilled water). Both slides were covered with a cover slip and observed under the microscope at 10x and at 40x magnifications. Saline preparation and iodine allowed for visualization of motile trophozoites and cysts, respectively.

2.10. Data Management and Statistical Analysis. Data collected were checked to ensure accuracy and completeness on site before double entry into a Microsoft Excel spreadsheet. The observed prevalence of *S. mansoni* and intestinal protozoa infections were calculated by school, as well as by demographic variables, and the 95% confidence intervals (CIs) were obtained using binomial logistic regression, taking into account clustering by schools. For purposes of this analysis, the following age groups were used: <10, 10–12, and >12 years. Using univariable analysis, factors associated with *S. mansoni* and intestinal protozoa infections were determined and described as odds ratio (OR). Minimum adequate variables for multivariable analysis were selected by specifying an inclusion criterion of p value <0.05 in a sequential (block-wise) variable selection method. Adjusted odds ratios (aOR) were obtained by mutually adjusting all minimum generated variables using a multivariable logistic regression model. All statistical analyses were carried out using STATA version 14.1 (STATA Corporation, College Station, TX, USA).

3. Results

3.1. Sociodemographic, Household, and School Characteristics. The overall data were collected from 180 children in three primary schools in Mwea West. The mean age of children was 10.0 years (range: 7–15 years, standard deviation (SD) ± 1.6 years). There was an equal representation of study participants in terms of gender (50.0%/50.0%) females/males. Majority of the study participants were in the age group 10–12 years (99 participants; 55%), followed by those below 10 years (66 participants; 36.6%), and those above 12 years (15 participants; 8.3%).

Out of all the households surveyed, 35.6% (64 households) used improved water sources and 152 (84%) used improved latrines (VIP). All three schools used improved sources of water for drinking and had improved latrine facilities (VIP). For personal and environmental hygiene purposes such as handwashing and cleaning classrooms, Mianya and Mbui Njeru used water from unimproved sources (surface water) while Mukou used piped water (improved sources). The pupil per latrine ratio was 23 : 1, 67 : 1, and 17 : 1 for Mianya, Mbui Njeru, and Mukou primary schools, respectively.

3.2. Prevalence of S. mansoni and STH Infections. Only one case of STH (*A. lumbricoides*) was identified. The overall prevalence of *S. mansoni* was 70.5% (95% CI: 59.0%–84.2%). The mean infection intensity was 376.2 epg (95% CI: 222.3–530.1) and was categorized in overall as moderate infection. Majority of the infections were light infections 46 (25.6%), followed by moderate infections 41 (22.8%) and severe infections 40 (22.2%). Out of the three schools,

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Table 3: Multivariable analysis of risk factors of *S. mansoni* and any intestinal protozoa infection.

Characteristic	Multivariable analysis (aOR, p value)	
	S. mansoni ($n = 127$)	Any protozoan ($n = 59$)
Demographics		
School		
Mianya	1.23, $p = 0.001$*	2.03, $p = 0.001$*
Mbui Njeru	Reference	Reference
Mukou	3.19, $p = 0.001$*	0.55, $p = 0.001$*
Age group		
<10 years	Reference	
10–12 years	1.37, $p = 0.649$	—
>12 years	3.19, $p = 0.015$*	—
Gender		
Female	Reference	
Male	1.29, $p = 0.455$	2.41, $p = 0.001$*
Individual and household characteristics		
Use of anal wiping material	—	0.55, $p = 0.019$*
Handwashing after defecation at home	0.39, $p = 0.001$*	—
Water contact	—	0.32, $p = 0.001$*
Behavior of wearing shoes at home	1.67, $p = 0.010$*	—

*Significant association ($p < 0.05$).

only collected from three schools and may therefore be inadequate to make inferences. The laboratory methods used for the detection of the intestinal parasitic infections were of limited sensitivity and may have underestimated the prevalence of infections. Identification of the pathogenic *E. histolytica* from the enteric commensals *E. dispar* was not differentiated due to lack of laboratory facilities in the department.

6. Conclusion

Infections with *S. mansoni* and intestinal protozoa as well as their coinfection are a public health problem in school children in the Mwea irrigation scheme. The hygiene behavior of handwashing at home was protective against *S. mansoni* infections while use of wiping material and water contact was protective against any protozoan infection. However, wearing shoes at home was a risk factor for *S. mansoni* infection. These findings show that WASH factors at the household level have a significant role in transmission. Also, consistency of deworming for *S. mansoni* infections and treatment for intestinal protozoa infections are necessary. These treatments should be complemented with improvements in school and household WASH conditions and behavior education on hygienic habits.

Abbreviations

- aOR: Adjusted odds ratio
- BCC: Behavior change communication
- CI: Confidence interval
- epg: Eggs per gram of feces
- ESACIPAC: Eastern and Southern Africa Centre of International Parasite Control
- KEMRI: Kenya Medical Research Institute
- MDA: Mass drug administration
- OR: Odds ratio
- SBD: School-based deworming
- SD: Standard deviation
- SERU: Scientific Ethics and Review Unit
- STH: Soil-transmitted helminths
- WASH: Water, sanitation, and hygiene
- WHO: World Health Organization.

Data Availability

The datasets used to support the findings of this study are available from the corresponding author upon request.

Ethical Approval

The study protocol received ethical approval from the Kenya Medical Research Institute (KEMRI), Scientific Ethics and Review Unit (SERU no. 3093). Permission to conduct the study was sought from the County Health and Education Authorities. School authorities and parents/guardians were informed about the study, and participation was fully voluntary.

Consent

Written informed consent and verbal assent were obtained from participants' guardian/parent and children above 13 years of age, respectively. Treatment was administered to participants infected with intestinal parasitic infections by a medical professional. For *S. mansoni* infections, 40 mg/kg body weight of praziquantel was administered according to the WHO guidelines [22]. Intestinal protozoa infections were treated with metronidazole 20 mg/kg per day for 5 days [12].

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

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