UNIVERSITY OF NAIROBI

PREVALENCE AND ASSOCIATED RISK FACTORS OF INTESTINAL PARASITIC INFECTIONS IN OLOISUKUT CONSERVANCY COMMUNITY, NAROK COUNTY, KENYA

BY

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DEPARTMENT OF BIOLOGY

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DECLARATION

I declare that this thesis is my original work and has not been submitted elsewhere for examination or award of a degree. Where other people's work has been used, this has been properly acknowledged and referenced in accordance with the University of Nairobi's requirements

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DEDICATION

I honor my parents, Mr. Michael Gitau and Mrs. Joyce Muiruri, who gave birth to me by dedicating my work to them. They have worked hard to provide for me, they have sacrificed a lot to see me through school and have been instrumental in my academic journey through their prayers, moral and financial support. I appreciate their mentorship, support and for believing in my abilities. To my sister Mary who I look up to and for setting high standards for me to follow. To my brother Edwin, who has always supported me and my niece Mayah, born months before I began my masters for bringing so much joy to our lives.

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TABLE OF CONTENTS

Page

LIST OF PRESENTATIONS RELATED TO THE THESIS

Oral presentations

1. **Zipporah Gitau**, Erastus Mulinge, Eberhard Zeyhle, Jackson Mpario, Tabitha Irungu, Joyce Nyambura, Japhet Magambo, Malika Kachani, David O. Odongo., One Health Studies at the Human Animal-Environment interface in the Oloisukut Conservancy, Narok County. Prevalence of intestinal parasitic infections in humans, Kenya, Kenya One Health Conference, 6-8th December 2021, International Livestock Research Institute (ILRI), Nairobi.
2. **Zipporah Gitau**, Erastus Mulinge, Eberhard Zeyhle, Jackson Mpario, Tabitha Irungu, Joyce Nyambura, Japhet Magambo, Malika Kachani, David O. Odongo**.,** Prevalence of intestinal parasitic infections in the community of Oloisukut Conservancy, Narok County, Kenya, 12th KEMRI Annual Scientific and Health Conference (KASH 2022), 16-18th February 2022, Safari Park hotel Nairobi.
3. **Zipporah Gitau**, Erastus Mulinge, Eberhard Zeyhle, Jackson Mpario, Tabitha Irungu, Joyce Nyambura, Japhet Magambo, Malika Kachani, David O. Odongo**.,** Prevalence and associated risk factors of intestinal parasitic infections in Oloisukut Conservancy community, Narok County, Kenya, 5th Annual Conference of the Faculty of Science and Technology, University of Nairobi, Kenya held on 26 – 28th October 2022.

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS AND ACRONYMS

AOR-Adjusted Odds Ratio

CDC- Centre for Disease Control and prevention

CI-Confidence Interval

CMR-Centre for Microbiology Research

DALYS- Disability Adjusted Life Years

EPG-Egg Per Gram

GAHI- Global Atlas of Helminth Infections

IPIs-Intestinal Parasitic Infections

KEMRI-Kenya Medical Research Institute

M&E-Monitoring and evaluation

MDA-Mass Drug Administration

NSBD-National School- Based Deworming program

NTD-Neglected Tropical Disease

OR-Odds Ratio

PCR-Polymerase Chain Reaction

PI- Principal Investigator

PPE-Personal Protective Equipment

PSAC -Pre-School Age Children

SAC-School Age Children

SD-Standard Deviation

SOP-Standard Operating Procedures

SPP-Species

SPSS-Statistical Package for the Social Sciences

STH-Soil Transmitted Helminth infections

WASH-Water, Sanitation and Hygiene education

WHO-World Health Organization

ABSTRACT

Globally, approximately 1.4 billion people suffer from soil-transmitted helminth infections with disease burden estimated at 5.3 million Disability Adjusted Life Years. Mass drug administration (MDA) remains the World Health Organization recommended control strategy. In 2012 the Kenya government initiated a national school-based deworming program (NSBD) among school children living in high-risk environments. This program however, faces the challenge of re-infections with the factors leading to this being poorly understood. Furthermore, the program neglects non-school age children and adults who may serve as potential reservoirs of infections within the community. A cross sectional community-based descriptive study was conducted to determine the prevalence of intestinal parasitic infections (IPIs) and its associated risk factors among the community living in Oloisukut Conservancy, Trans Mara, Narok County, Kenya. Human fecal samples were collected and microscopically examined for detection of intestinal parasites using the Kato-Katz and formal-ether concentration techniques prior to treatment with mebendazole. A total of 411 fecal samples from family members aged ≥ 2 years and representing 92/483 families were collected and examined. Structured questionnaires were administered to determine risk factors associated with IPIs. Results from stool examination were linked to questionnaire responses. Univariate and multivariate analysis in a random mixed effects logistic regression model and described as odd ratio (OR) were used to examine the relationship between IPIs and associated risk factors. A $p<0.05$ was considered significant in all analysis. The prevalence of IPIs was 62.5% at baseline and 53.9% at endline survey. Prevalence of intestinal protozoa and helminths was 46.2% and 39.9 % respectively. Eleven genera of intestinal parasites were observed at baseline survey. The intestinal helminths observed were *T. trichiura* (36.7%), followed by *A. lumbricoides* (5.6%), Hookworm (2.7 %), *H. nana* (1.2%), *Taenia* spp. (0.7%) and *S. stercolaris* (0.2 %). The intestinal protozoa observed were *E. histolytica/E. dispar/E. moshkovskii* (31.6%) and *G. lamblia* (9.7 %). Non-pathogenic protozoa observed were *E. coli* (24.6%), *I. buetschlii* (8.5%) and *C. mesnili* (1.0%). More males compared to females were infected with IPIs. School going children (5 -14 years) bore the highest burden of infections. Polyparasitism was more prevalent (35.3%) compared to single infections (27.3%). STH prevalence decreased from 39.9% at baseline to 19.2% at end line, with a relative reduction rate of 58.4%. Age was the only risk factor linked to IPIs in this study. The presence of *Taenia* spp. is suggestive of zoonotic transmission within this community. Based on the high prevalence of helminth infections among community members typically not targeted by the MDA national deworming programs, this study recommends inclusion of the entire community in preventive chemotherapy intervention within the national NTD elimination and deworming programs. This study further suggests the need to integrate management of intestinal protozoan infections with the national deworming programs.

CHAPTER ONE: INTRODUCTION

1.1 Background

Intestinal parasitic infections (IPIs) mainly protozoa and helminths are a major public health concern in most developing countries with reported high prevalence and morbidity within tropics and subtropics despite the elaborate measures available for their control (Speich *et al*., 2016). These infections are mostly asymptomatic and, in few cases, manifest only as mild symptoms. They are mostly ignored and attention is only given when they cause severe or chronic complications (Bahmani *et al*., 2017). Moreover, poverty, ignorance, political instability and little or no political goodwill to prioritize and mount effective control programs to eradicate parasitic diseases attribute to high disease burden. IPIs affect the poor living in marginalized communities deprived of clean water, proper sanitation together with good hygiene (Okoyo *et al*., 2020).

Intestinal parasite infections affect more than 3.5 billion people globally. Out of these, 450 million people are infected with intestinal protozoa. IPIs cause 450 million morbidities and 200,000 mortality annually (Kiani *et al*., 2016; Tegen and Damtie, 2021). A quarter of a billion people worldwide, or 1.5 billion people, experience helminth-related suffering (Clarke *et al*., 2018; Kabatende *et al*., 2020). An estimated 5.3 million disability-adjusted life years (DALYS) are lost to soil-transmitted helminths (STH) illness (Leuenberger *et al*., 2016). Globally, 5.3 billion and 143 million people dwell in habitats with stable and unstable STH transmission respectively (Pullan and Brooker, 2012). The Global Atlas of Helminth Infections (GAHI) reported that more than 9.1 million people in Kenya were at risk of STH, and school children accounting for 2.4 million (Brooker *et al*., 2010).

The common intestinal helminths are STHs namely; *Ascaris lumbricoides, Trichuris trichiura* and Hookworm: (*Necator americanus* and *Ancylostoma duodenale*) (Pullan *et al*., 2011; Montresor *et al*., 2020). Globally, approximately, 1,221 million people suffer from *A. lumbricoides*, 740 million from Hookworms while 795 million from *T. trichiura* (de Silva *et al*., 2003). The two most often encountered

intestinal pathogenic protozoa are *Entamoeba histolytica and Giardia lamblia.* (Kamande *et al*., 2015). About 50 million people suffer from Amoebiasis and 280 million people suffer from asymptomatic Giardia infection annually. *Blastocystis hominis*, *Cryptosporidium parvum* and *Isospora* are also common opportunistic intestinal protozoa that cause diarrhea in children and immunocompromised patients (Mbae *et al*., 2013).

IPIs cause high morbidity, malnutrition, malabsorption, impair physical and cognitive growth, and are a threat to good health and access to education particularly in children (Ahmed *et al*., 2011; Kabatende *et al*., 2020). These infections cause untold suffering and reduced productivity. IPIs are spread via fecal oral pathway by consuming infectious eggs (for ascariasis and trichuriasis) and cysts (for *E.histolytica*, *G.lamblia* and *Cryptospridium* species) in food, water, or hands that have been in contact with human waste. Infection with hookworm is through active skin penetration of infected larvae present in contaminated soil. Predisposing risk factors include; lack or inadequate safe water for drinking, lack of proper sanitation facilities, poor food and personal hygiene, indiscriminate waste disposal, improper handling of animals, use of night soils and raw sewer for irrigation, crowding and climatic conditions. Inadequate education on causes, transmission and outcomes of intestinal parasites further aggravate the situation (WHO, 1987; Liao *et al.*, 2016).

The occurrence and risk of developing IPIs in rural communities in Africa is poorly understood. These rural communities are considered endemic areas due to their low social economic status, inadequate sanitation and other geographical factors. High prevalence of IPI has been found in earlier research studies conducted in Kenya (Kamau *et al*., 2012; Kipyegen *et al*., 2013; Kamande *et al*., 2015; Kamonge *et al*., 2019). Due to great diversity in geographical factors and social cultural behaviors in different areas in Kenya, separate epidemiological studies are required in each region.

More than 270 million pre-school and 600 million school-aged children (SAC) live in IPIs endemic regions (Tegen and Damtie, 2021). In Kenya, SAC account for 42% of the population with

approximately six million at risk of IPIs and requiring deworming (Brooker *et al*., 2000; Okoyo *et al*., 2020). SAC are disproportionately affected due to their weak immune systems and complex nutritional need during their active stage of growth. Their close association with contaminated soil and general low levels of sanitary hygiene exposes them to high risk of infections with these parasites. They are therefore important for maintenance and transmission of IPIs (Korkes *et al*., 2009). In addition, asymptomatic pre-school children and adult carriers in the community may also serve as important reservoirs of most intestinal parasitic infections contributing to increased community transmission.

The WHO recommends mass drug administration (MDA) of anthelminthic medications given annually to pre-school children (2–5 years), school children (5–14 years), and women of child bearing age in order to prevent intestinal helminthic infections and its associated morbidity. Along with routine monitoring and surveillance, this is integrated with the supply of clean water, sanitation, hygiene (WASH), and behavior change (Clarke *et al*., 2018). Many countries have launched national control programs on helminthiasis aimed at achieving deworming coverage rates of 75% of all school going children (Montresor *et al*., 2020). Following the WHO recommendation, the Kenyan government initiated a National School-Based Deworming program (NSBD) in 2012, aimed at controlling helminth infections and reducing the associated morbidity among school going children living at high-risk areas (Okoyo *et al*., 2016). The program mainly targets highly endemic areas for soil-transmitted helminths and schistosomiasis. The Ministry of health in 2018 reported that approximately 5.97 million children across 16,000 schools in over 27 endemic counties had been dewormed since inception of the NSBD (Okoyo *et al*., 2020). Earlier, a 25% reduction in school absenteeism was observed following mass drug administration in western Kenya (Brooker *et al*., 2000).

Despite the WHO recommendation advocating for periodic deworming of all at-risk groups, most national deworming initiatives in endemic countries, Kenya included, only target the MDA to SAC, whilst neglecting the pre-school children and adults who are potential reservoirs of infections within the

same community. For this reason, school-based deworming programs are considered ineffective to mitigate re-infections at the community-level, as infected adults are likely to sustain transmission. Previous studies have reported that use of community-based MDA policy could considerably reduce transmission, and eliminate STHs (Anderson *et al*., 2015). Preventive chemotherapy programs for STHs infection in SAC are done semi-annually (where prevalence >50%), and annually (where prevalence is 20% - 50%). No preventive chemotherapy is done if prevalence is <20% (Crompton, 2006). There is no WHO recommendation on preventive chemotherapy or MDA for intestinal protozoa.

Current control strategies for STHs entail use of age-targeted preventive chemotherapy. WHO, (2010) and Halliday *et al*., (2019) noted that focus should shift to evaluating the most effective, efficient and sustainable preventative chemotherapy plans, with a possibility of shifting from age-targeted to community-based MDA. The gold standard Kato-Katz method is used in the current WHO regulations for monitoring and evaluating (M&E) STH control programs and done five to six years following preventive MDA (Giardina *et al*., 2019).

1.2 Statement of problem

Previous M&E studies on national school-based deworming programs (NSBD) in the greater Narok county reported a high prevalence of soil-transmitted infections (STH) (53.0%) at baseline while after a 5-year deworming and follow up, STH prevalence was reported at 43.1% (Mwandawiro *et al*., 2019). The factors influencing this situation (re-infection or total reduction) are poorly understood in most rural communities of tropical sub-Saharan Africa. The frequency of IPIs remains high in many rural areas despite availability of cost-effective and safe interventions to control them. This is because deworming programs do not protect children from re-infection of intestinal parasites such as *A. lumbricoides* which may re-occur following treatment (Jia *et al*., 2012). Moreover, the NSBD program is school-based rather than community based, and thus unable to control community transmission further risking dewormed children to re-infections. Pre-school children and adults are typically not included in control programs

with arguments that they harbor insignificant burden of IPIs (Truscott *et al*., 2014; Masaku *et al*., 2020). Cases of drug resistance to commonly used deworming drugs have also been reported (Tinkler, 2020). Moreover, the program does not mitigate for environmental contamination with parasites present in fecal matter, and the potential risk of anthroponotic and zoonotic transmission particularly in areas where open defection is rampant (Jia *et al*., 2012; Mwandawiro *et al*., 2013; Okoyo *et al*., 2016).

1.3 Justification of the study

A previous geospatial mapping of IPIs particularly the soil transmitted helminths was done in Kenya to determine endemic areas. According to the report, STH were prevalent mainly within Western, South Rift valley, Nyanza as well as Coastal regions. Central and North Eastern regions had prevalence levels which did not warrant deworming in accordance to WHO decision trees (Pullan *et al*., 2011). Monitoring and evaluation surveys done on NSBD program reported that the prevalence of IPIs in the larger Narok County before deworming was 53%. Following deworming, the prevalence reduced to 43.1% with factors leading to reduction in prevalence being poorly understood. In addition, deworming was carried out annually in only selected schools in the area and not to the whole population. This study thus determined prevalence, parasitological outcomes and risk factors linked to intestinal parasitic infections pre and post mass administration scheduled at 3 months apart to the community living in Oloisukut Conservancy, Trans Mara, Narok County. This study was nested on a larger project " A one health intervention project in the Oloisukut Conservancy, Transmara, Narok County, Kenya" which estimated prevalence and risk factors of zoonotic diseases of human and animal importance in the community. The wildlife and animal component of the study had been done leaving a gap of the human component.

Epidemiological research is important to generate data on the current status and trends of IPIs as well as identify high at-risk areas for localized adequate control programs to be developed. Carrying out research on IPIs in different locations is crucial in order to detect high-risk areas, design and evaluate effective control and intervention programs. Due to great diversity in geographical factors and social

cultural behaviors in different areas in Kenya, epidemiological studies are separately required for each region. Prevalence of IPIs among the community residing at Oloisukut Conservancy area of Narok County is lacking. Given that intestinal parasites are linked to poverty and poor sanitation, they remain of public health concern. Determining the burden of intestinal parasite infections and the risk factors that go along with them is therefore necessary to aid in the design of national control and elimination programs. Data obtained will provide information on prevalence, associated risk factors and impact of preventive chemotherapy during MDA on prevalence of IPIs among the community living in and around Oloisukut Conservancy, and inform the program's next step.

1.4 Research questions

1. What is the prevalence of intestinal parasitic infections among the community living in Oloisukut Conservancy?
2. What is the impact of mass drug administration on prevalence of intestinal parasitic infections among the community living in Oloisukut Conservancy?
3. What are the risk factors associated with intestinal parasitic infections among the community living in Oloisukut Conservancy?

1.5 Objectives of the study

1.5.1 General objective

To determine prevalence and associated risk factors of intestinal parasitic infections in Oloisukut Conservancy Community, Narok County, Kenya.

1.5.2 Specific objectives

The specific objectives of the study were;

i. To determine prevalence of intestinal parasitic infections among the community living in Oloisukut Conservancy.

ii. To evaluate impact of mass drug administration on prevalence of intestinal parasitic infections

among the community living in Oloisukut Conservancy.

iii. To assess the risk factors associated with acquisition of intestinal parasitic infections among the community living in Oloisukut Conservancy.

CHAPTER TWO: LITERATURE REVIEW

2.1 Epidemiology of Intestinal Parasitic Infections

The geographical burden of IPIs varies significantly. Highest burden of IPIs occur in East Asia, China, America, and sub-Saharan Africa (Pullan *et al*., 2014). IPIs are common in rural areas with warm-humid climates, strongly linked with poverty, poor sanitation and hygiene (Okoyo *et al*., 2020). IPIs are also prevalent in urban settings. School going children (5-14 years) in particularly are susceptible to IPIs and are habitually exposed to polluted environment while playing, eating food with soiled hands, eating unwashed fruits and raw vegetable, drinking untreated water and swimming or bathing in polluted water (Bethony *et al*., 2006; Okoyo *et al*., 2020).

Neglected tropical diseases (NTDs) caused approximately 26 million DALYs worldwide in 2010, of these, IPIs constituted the greatest burden. There are more than 3.5 billion people impacted by parasitic illnesses worldwide. Moreover, 1.5 billion individuals have STH, making them the most prevalent intestinal helminths. An additional 4 billion people are at risk. STH in particular contributes to 5.2 million DALYs, and 62% of this are largely caused by Hookworm (GAHI, 2022). Annually, intestinal protozoa cause 450 million morbidities and 200,000 mortalities (Tegen *et al*., 2020). Infections with schistosomiasis affect 200 million people and over 700 million at risk. Out of this, 90% of infected individuals reside in Africa (Pullan *et al*., 2014). *E. histolytica* affect more than 500 million people worldwide with an incidence rate of 5 million cases, causing 50 million morbidities and 100,000 mortalities annually. Additionally, 2.2 million disability-adjusted life years are lost due to Amoebiasis (Tegen *et al*., 2020). Each year, 280 million are infected with *G. lamblia/G. duodenalis*. Giardia infections are thought to cause 2.5 million cases of diarrhea annually in nations with limited resources. Children less than ten years old are the most affected and Giardia infections start early in infancy—about 30% (Laishram *et al*., 2012). *Cryptosporidium* results in of 8.37 million disability adjusted life years lost (Pisarski, 2019).

In developed countries, global prevalence of cryptosporidiosis range 1- 4.5%. However, in undeveloped nations, prevalence range 3-20%. Cryptosporidiosis infection is high among patients with AIDS with a reported prevalence of 3-20% in America and 50 -60% in Africa and Haiti (Mohammed *et al*., 2017).

In Kenya, studies on IPIs among children <5 years from urban slums in Nairobi reported a prevalence of 25.6% (Mbae *et al*., 2013) . Similarly, studies done in informal-settlements in Nakuru town had an overall prevalence of 17.3% (STH- 1.2% and protozoan parasites 41.7%) (Chege *et al*., 2020). According to studies on preschool children in Mwea, *S. mansoni* and *G. lamblia* were the most common parasites (Sakari *et al*., 2017). Another study in the same area recently recorded a prevalence of *S. mansoni* (70.5%), 32.7% of intestinal protozoa infections and only a single *A. lumbricoides* case seen. Co-infections were at 22.8% (Njambi *et al*., 2020). In Nandi, ascariasis was most prevalent 42–74% (Mulambalah and Ruto, 2016). Okoyo *et al*., (2016) survey on NSBD in Kenya reported that at baseline, STH infections had an overall prevalence of 32.3%. Following MDA, prevalence reduced to 16.4%. A recent survey in Kenya reported STH overall prevalence of 12.9% following MDA (Okoyo *et al*., 2020). Prevalence reduced significantly in all infections except *S. mansoni* (Mwandawiro *et al*., 2019).

2.2 Intestinal helminths

STHs are one of 17 NTDs that had been earmarked by WHO for control and elimination by 2020 (Legge *et al*., 2020). Children suffer the most and are physically and nutritionally impaired. The most common intestinal helminths affecting people are *A. lumbricoides* (roundworm), *T. trichiura* (whipworm,), and Hookworms' species (*N. americanus, A. duodenale* and *A. ceylanicum*) (Cheesbrough, 2006; Kabatende *et al*., 2020). STHs are spread by infective eggs present in contaminated soil (Cheesbrough, 2006). Warm climates, well aerated soils, and moisture are important during embryonation of eggs and larvae development. Enterobiasis is also common in children with prevalence ranges from 4-28% worldwide. Hymenolepiasis is a common zoonotic intestinal disease caused by *Hymenolepis diminuta* and *Hymenolepis nana*. Of the two, *H. nana* is most common among humans estimated to affect 1.75 million

people worldwide. *Taenia saginata* is a zoonotic intestinal parasite whose distribution is sporadic and common in areas with livestock production (Cheesbrough, 2006).

2.2.1 Life cycle and transmission of common intestinal helminthic infections

2.2.1.1 Soil-transmitted helminths

They are common parasites that inhabit the gut and produce thousands of eggs passed out with feces. Under favorable environment, eggs develop into infective forms. Humans acquire the infections passively by ingesting infective eggs (in case of *A. lumbricoides* and *T. trichiura*) or larvae (*A. duodenale*) in contaminated food or hands and actively through skin penetration of infective Hookworm larvae in faecally polluted soil. The eggs when passed out with feces are uninfective and require about 3 weeks for embryonating to develop into infective forms. Hence, no direct infection or person to person transmission is acquired from fresh stools (Cheesbrough, 2006).

2.2.1.2 Strongyloides stercolaris

The filariform larvae (infective) on contact with a suitable host penetrate skin such as foot. Autoinfection is also common. Within the human host, the larvae will migrate, pass up the trachea tree, swallowed into small intestines and develop into mature adult worms. Adult worms lay eggs. Eggs are passed out with the feces into the environment where they hatch into free living rhabditiform larvae and under optimal condition develop into infective filariform larvae or may develop into infective filariform larvae in the intestines, resulting in autoinfection (Cheesbrough, 2006).

2.2.1.3 *Schistosoma* spp

Blood flukes of the genus Schistosoma spp. cause schistosomiasis. It's a cyclic waterborne disease and needs two hosts to complete its lifecycle. The free in water living cercaria penetrates skin when people are in contact with contaminated water. In the human body, the cercaria develops into schistosomula that migrate through lungs and liver and develop into mature adult flukes in portal venous where they pair and migrate into the capillary blood vessels. Adult worms shed eggs which are passed out in feces or

urine into surrounding environment (water bodies). Eggs develop into miracidia after they hatch which enter the snail host . They transform into sporocysts. Sporocysts develop into cercaria that leave the snail host and penetrate actively into host (human) (Cheesbrough, 2006).

2.2.1.4 *Taenia* spp

Transmission occurs when cysticerci are consumed in raw and undercooked meat. In the small intestines, the cysticerci attach and develop into adult tapeworms which shed gravid filled segments which are passed with feces into the environment. They break open releasing eggs into the environment which are ingested by suitable hosts; cattle (*T. Saginata)* and pigs (*T. Solium)*. The eggs develop into infective cysticerci in muscles of the host (Cheesbrough, 2006).

2.3 Intestinal protozoa

The major intestinal protozoa parasites are *E. histolytica* and *G. lamblia*. Amoebiasis is caused by *E. histolytica*. It ranks third among all parasite infections as a cause of death worldwide. It affects all age groups in people; however, it is severe among children and is largely the common infection in institution like orphanages and community living in poor hygienic conditions. *G. lamblia* is a flagellate enteric common intestinal protozoan in third world countries and a common parasite infecting cat (Speich *et al*., 2016). Giardia infection cause acute and chronic diarrhea in children with an estimated prevalence of 10%-50 % in developing countries and between 2% and 5% in developed countries (Choy *et al*., 2014). Other common intestinal parasites are *Cryptosporidium* spp. and *Blastocystis hominis* reported to be an opportunistic protozoan parasite. *Balantidium coli* is a common commensal of large intestines of wild and domestic pigs. It is occasionally pathogenic to man and the only ciliate parasitizing man. It is hyperendemic in areas of New Guinea, Iran and Pacific islands where there is close human pig contact with prevalence rates of 20% (Cheesbrough, 2006).

2.3.1 Life cycle and transmission of intestinal protozoa parasites

2.3.1.1 Entamoeba histolytica, Giardia lamblia, Balantidium coli

Infective trophozoites and cysts are passed in feces. Humans contract the disease when they consume mature infective cysts found in food, water, or on hands that have been exposed to human waste. Direct oral fecal contact between family members or children in daycares can result in the transfer of Giardia infection, as can oral-anal contact (Choy *et al*., 2014). In small intestines, excystation occur and trophozoites are released. Trophozoites multiply in intestines through binary fission and encyst producing cysts. Infective cysts are passed in feces and contaminate the environment (Cheesbrough, 2006). Cyst can withstand harsh environmental conditions and remain infective for several months (Choy *et al*., 2014). Co-infections are common due to similarity in the transmission cycles (Njambi *et al*., 2020).

2.3.1.2 *Isospora belli, Cryptosporidium* spp., *Cyclospora cayetanenis* and other coccidian spp

Transmissions occur when infective oocysts are ingested by human. Oocysts excyst in lumen of small intestines releasing sporozoites which penetrate into intestinal cell and develop into trophozoites. Multiplication occurs through schizogony and merozoites which are released and infect new cells. Merozoites differentiate into female and male gametes. Fertilization occurs to form zygotes that differentiate into oocysts. Oocysts undergo sporogony and produce sporozoites. Sporulated oocysts are then passed in feces and contaminate food and water in the environment (Cheesbrough, 2006).

2.4 Clinical symptoms of intestinal parasitic infections

Intestinal parasitic infections cause serious health issues. The most disproportionately affected group of people is the children. STH cause debilitating effects in children. They are key causes of malnutrition and anemia due to nutritional deficiency resulting from these infections. In addition, they contribute to growth retardation, diminished physical fitness and delayed growth in intelligence and cognition (Ahmed *et al*., 2011; Ahmed *et al*., 2012). Infections with soil-transmitted helminths present a broad spectrum of symptoms like diarrhea, abdominal pain, intestinal obstruction, growth retardation, appetite

loss, vomiting, vitamin A deficiency and impaired cognitive process. Furthermore, they cause hepatic abscess, cholangitis, brain and ocular disorders, obstructive jaundice, acute pancreatitis, epilepsy and death in more extreme cases. Hookworms mainly cause chronic intestinal bleeding which result in anemia (Kabatende *et al*., 2020; Tegen and Damtie, 2021). Hymenolepiasis is mostly asymptomatic but in severe cases present with abdominal pain, diarrhea, anorexia and other gastrointestinal symptoms that are non-specific. Common symptom of taeniasis is abdominal pain, dizziness, headache, tingling skin, diarrhea, intestinal obstruction and loss of appetite (Harizanov *et al*., 2020).

Amoebiasis cause asymptomatic infection in most cases, invasive intestinal amoebiasis characterized by dysentery, and invasive extracellular amoebiasis characterized by liver abscess. Giardiasis mostly affects children with severe cases experiencing persistent acute diarrhea, abdominal pain, flatulence, fatigue, nausea, poor nutrient absorption and impaired cognitive growth (Bethony *et al*., 2006). Giardiasis is linked with fat malabsorption and lactose deficiency and result in 2.5 million deaths annually (Choy *et al*., 2014). *Cryptosporidium* spp., *Isospora belli* and *Cyclospora cayetanenis* cause enteritis with secretory diarrhea. *Cryptosporidium* spp. are normally found in humans without any harmful effects. They have frequently been linked to watery diarrhea among immunocompromised patients and children (O'Connor *et al*., 2011). *Blastocystis hominis* is associated with severe enteritis. However, its parasitic status has not been clearly elucidated (Kurt *et al*., 2016).

2.5 Pathogenicity of intestinal parasitic infections

Pathogenicity of intestinal parasites is due to several factors; parasite, host and social economic factors. Parasitic factors include: parasite strain, host adaptation, parasite density and habitat. Host factors entail: demographic factors i.e., age and gender, genetic factors, nutritional status, status and response of natural immunity, infection intensity and presence of existing diseases. Social economic factors; crowding, inadequate sanitation facilities, poverty, and lack of safe drinking water all affect pathogenicity (WHO, 1987).

2.6 Prevention, Control and treatment of intestinal parasitic infections

WHO global goal was elimination of STHs morbidity in all high-risk individuals (pre-school children 2–5 years, SACs aged five to fourteen and women of child bearing age) by 2020, described as a decrease in prevalence to <1% (Clarke *et al*., 2018). Additionally, the WHO treatment plan recommends annual or bi-annual preventive MDA, covering at least 75% of the aforementioned risk groups (Giardina *et al*., 2019). Basic control approach of intestinal parasites is improved sanitation, safe waste disposal, availability of clean drinking water; promote personal and food hygiene, social economic and health education. These above strategies need to be complemented with chemotherapy. A cluster randomized school-based trial previously done in Kenya revealed latrine construction, WASH strategies and MDA had 44% odds of reducing prevalence of *A. lumbricoides* (Freeman *et al*., 2013).

Anthelminthic drugs of choice used to treat STH are mebendazole and albendazole dosed at single-dose albendazole 400mg or mebendazole 500 mg, levamisole or pyrantel (Giardina *et al*., 2019; CDC, 2020). Nitroimidazoles are drugs of choice for treatment of amoebiasis and other intestinal protozoa. Moreover, improved water, sanitation and hygiene (WASH) have been reported that they can accelerate reduction and interruption of transmission and safely stop MDA use without a risk of re-infection (Okoyo *et al*., 2021b). There are no recommended control strategies for intestinal protozoa infections.

2.7 Diagnosis of intestinal parasitic infections

Unfortunately, due to a lack of knowledgeable and skilled staff and inadequate technology, IPIs frequently go untreated. It is further harder to diagnose when eggs or larvae intermittently shed. The gold standard method for diagnosing IPIs is by identifying protozoan cysts and helminths eggs in stool sample using a microscope. However, in case of light infections, concentrations methods are recommended. Endoscopy and colonoscopy are used to detect intestinal parasites. Usually, a tube is inserted in mouth (endoscopy) or rectum (colonoscopy) and examination of the intestines done to check for any parasites

or abnormalities. Fecal culture/copro culture test is also used to identify parasites in stools that cause gastrointestinal infection. Blood tests such as serology, Immunodiagnostic tests such as ELISA, Immunofluorescence essays and PCR all showed good sensitivity in diagnosis of intestinal parasites (Cheesbrough, 2006).

2.8 Risk factors associated with IPIs

Previous studies have sited age and gender as a risk factor strongly linked to IPIs. Subsequently, SAC are disproportionately at high risk of IPIs (Njambi *et al*., 2020; Tegen and Damtie, 2021). Poverty, poor hygiene practices, host nutritional and immune status, parasite strain, lack of latrines, soil contact, overcrowding, source of drinking water, impoverished health services, poor socioeconomic conditions as well as fecally polluted water are some of the risk's factors linked to IPIs (Kotian *et al*., 2014; Njambi *et al*., 2020; Tegen and Damtie, 2021).

Other risk factors that have been linked to IPIs include; goat rearing, earthen floor , not wearing shoes, large family size, location of homes near water bodies, drinking untreated water, close contact with domestic animals in homes, consumption of raw vegetables and fruits, untrimmed finger nails, bathing in contaminated rivers, hand washing practices (Ahmed *et al*., 2011;Tulu *et al*., 2014 ;Choy *et al*., 2014 Sakari *et al*., 2017; Kamonge *et al*., 2019; Mwandawiro *et a*l., 2019; Chege *et al*., 2020). Previous prenatal research studies in New Zealand demonstrated a link between changing children's napkins and an elevated risk of giardiasis (Hoque *et al*., 2001). Low social economic background has also been showed to influence giardiasis as well as children younger than five years old (Mukherjee *et al*., 2009).

CHAPTER THREE: MATERIALS AND METHODS

3.1 Study area description

This study was conducted at Oloisukut conservancy which covers an area of 33,000 acres and is located in Oloolollo sub location, Kimintet location, Kirindon division, Trans Mara West, Narok County and within the larger Mara –Serengeti ecosystem. The map of the study area is shown in Figure 1. The area borders the Mara River from the east and Muyan River from the west which serves as a tributary of Mara River. Soils are dark brown , geology dominated by granite and terrain is open grassland with seasonal rivers. Geology is dominated by granite and terrain is open grassland with seasonal rivers. It has an altitude of 1500-2500 meters above sea level; Rainfall: 700-2300 mm, temperature range between 14.8^{o}C and 20.3°C (Mpario, 2011).

There are 483 families who live in the area with an estimated total population of 12500 (conservancy website). There are five villages namely Ilookwaya, Itolish, Kimintent, Nkinye and Pusanki within the conservancy. The study site is primarily rural community, with the economic activities being livestock rearing, tourism, quarrying and bee keeping (Mpario, 2011). The study area was chosen due to its proximity to Maasai Mara game reserve and the close interaction of the people with both domestic and wild animals which places them at risk of zoonotic diseases.

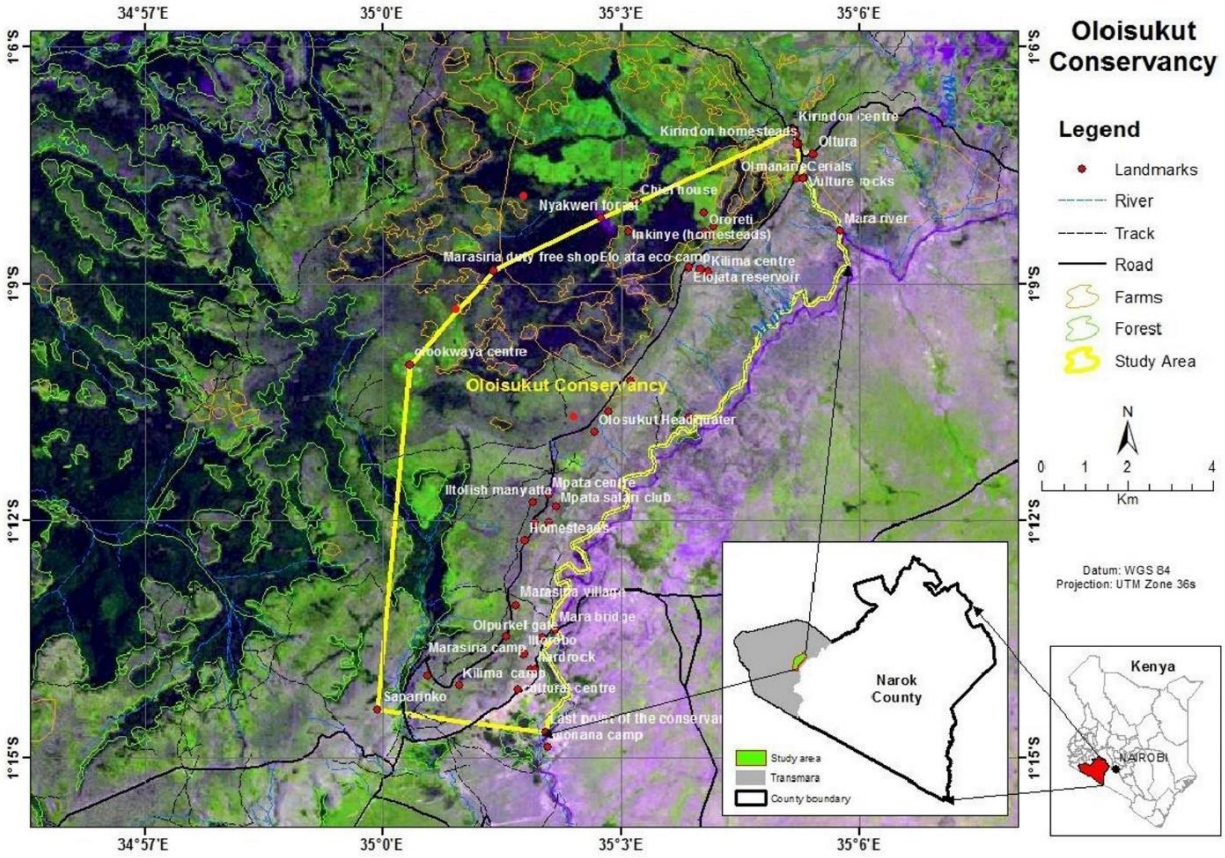

Figure 1: A map showing the location of Oloisukut Conservancy (Courtesy Mpario, 2011).

The study area is outlined in yellow. The conservancy is highlighted in green on the Narok county inset. The county is highlighted in red on the Kenya map inset. Other map markers are indicated on the map legend.

3.2 Study design.

A descriptive community-based cross-sectional study was conducted between the months of August to December 2021. The study was done in two phases. Initial baseline survey was done three months prior to deworming the participants in August 2021 while the second phase, follow up was done after deworming the study participants in December 2021. Information on the risk factors linked to intestinal parasite infections was collected using a standardized questionnaire.

3.3 Study populations

Human stool was obtained from all family members aged two years and above residing in Oloisukut conservancy for the past five years. A total of 92/483 families from all villages namely Itolish (76), Ilookwaya (67), Nkinye (44), Kimintet (180) and Pusanki (44) were randomly sampled in this study. There were 411 participants enrolled comprising of 77 preschool-age children ≤4 years old, 190 primary school children 5-14 years, 144 ≥ 15 years comprising secondary school children/adults.

3.3.1 Inclusion criteria

1. All family members who resided in and around Oloisukut Conservancy for the past five years.
2. Any family member who gave consent.
3. All family members aged two years and above.
4. All family members who had not been dewormed prior to this study.
5. Those who were willing to take mebendazole.
6. Any family member who had no any known history of hypersensitivity to benzimidazole class of compounds.

3.3.2 Exclusion Criteria.

1. A known or possible pregnancy, contraindicated for mebendazole in the first trimester.
2. Mothers nursing their newborn children, contraindicated for mebendazole in week one of puerperium.

3.4 Sample size calculation and sampling procedure

Previous research in Kenya found that intestinal parasite prevalence ranged from 5% to 45%. (Mwandawiro *et al*., 2019). We assumed a prevalence of 50% would give the maximum sample size. Applying a 95% confidence interval and a 5% margin error, sample size (*n*) was calculated utilizing modified Fisher's formula as described by (Mugenda et al., 1999).

$n = z^2pq/d^2$

n = Desired sample size

z = (1.96) Standard normal deviate

p = Prevalence of intestinal parasites used was 50%

q = 1.0 − p

d = Degree of accuracy

$n = (1.96)^2\ (0.5)\ (1.0–0.\ 5/\ (0.05)^2$

n = 384.16

Based on this formula, a total of 385 participants was calculated. To cater for low response rate, a 5% adjustment of the total sample size was added thus 411 individuals were randomly selected. A sampling frame of all homesteads based on the number of homesteads that benefited from a recent dog vaccination against rabies was estimated at 483 families with an average of 6 individuals per family and a total population of 12500. A minimum of 71 families were targeted. A list of the all families was drawn and 92/483 (19.0%) families randomly selected. Within each family, all were sampled.

3.5 Recruitment and consenting procedures

Prior to enrolment, a study site pre-visit was made to meet and sensitize the community on the purpose and objective of the study. Detailed information on procedures, expectations, benefits and risks were made apparent to the participants (Appendix III), and those who consented were enrolled into the study. The study participants filled a consent form (Appendix III,IV and V) with the assistance of the principal investigator (P.I) and afterwards, a structured questionnaire (Appendix 1/II) was administered. Consenting participants were assured of confidentiality.

3.6 Sample collection

Consenting individuals provided stool samples. Participants were instructed to collect and submit early morning stool samples for examination as per WHO guidelines (WHO, 1991). Each individual was given a clean sterile leak-proof capped container labelled with unique identifier, tissue paper, a piece of

newspaper and a bag. They were instructed to place the newspaper on the ground on to which they would defecate. The stool sample was placed in the bags provided and kept in cool or shaded area. The human fecal samples were transported to the nearby make-shift laboratory at the conservancy offices and recorded. Stool samples were processed and examined microscopically, using Kato-Katz and formal-ether concentration techniques as described in WHO guidelines (WHO, 1991).

3.7 Questionnaire survey

A structured questionnaire with multiple choice options was utilized to collect data in order to identify the risk variables related to IPIs. (Appendix I/II). It was written in English and translated into Kiswahili and Maa languages. Each household head was interviewed to obtain information on risk factors. Two important domains were addressed: social-demographic (i.e., age, gender, size of the family and education level) and hygiene habits (i.e., handwashing before and after meals, availability of toilets and usage, handwashing after defecation, intake of raw meat, water source, treatment of drinking water, washing vegetable and fruits before eating, shoe wearing habits, fingernail hygiene, children soil eating habits and water contact). Deworming habits and access to hospital facilities was also asked. The Open Data Kit (ODK) KoBo collect software integrated onto an android tablet was used for data collection and management. The program included built-in data quality checks to guard against any data entry mistakes. All responses were filled in using the tablet, and the data stored in a central server. The aggregated data was retrieved as downloadable XLS forms for analysis (KoboToolbox, 2022).

3.8 Deworming

After submitting a fresh stool sample the study participants were given single-dose mebendazole (500mg) administered orally by the study nurse well known to the community. The drugs were obtained courtesy of the Division of Vector Borne & Neglected Tropical Diseases-Ministry of Health, Kenya. Study participants were instructed to chew and swallow the drug under the supervision. The study nurse monitored for any adverse effects to medication. In addition, the principal investigator contacts

information as well as KNH-ERC ethics committee were given to all participants in the event of any query or complain they wished to be addressed.

3.9 Laboratory procedures

3.9.1 Kato-Katz method

The Kato-Katz technique was used to examine and quantify helminth eggs in fecal samples. The number of eggs were counted and expressed as eggs per gram (EPG) as described (WHO, 1991; Montresor *et al*., 1998a). According to WHO, the severity of an infection was categorized as light, moderate, or heavy (Table 1) (WHO, 1991; Montresor *et al*., 1998b). The fecal sample was mixed with a wooden applicator to evenly distribute the parasites in the sample. A small quantity (approximately 41.7 mg) of fecal sample was scooped into a sieve and pressed through to the concentrate feces. A flat-sided tongue depressor was then used to collect sieved sample. On a labelled microscope slide, a perforated template was placed and filled with the sieved stool sample while avoiding air bubbles. Excess feces were removed. The template was then carefully lifted leaving fecal specimen on the slide.

A cellophane strip pre-soaked in malachite green-glycerin solution was then placed on top of the fecal sample and acted as a coverslip. Any excess glycerol solution was wiped off using a paper towel. To spread out the fecal sample evenly, the microscope slide was inverted and the fecal sample was pressed hard against the hydrophilic cellophane on the work surface. To avoid detaching the cellophane strip from the fecal sample, the slide was gently lifted, inverted, and set on the workbench. Duplicate slides were prepared for each fecal sample and examined for presence of intestinal helminths eggs within 30–60 min following preparation. The slides were systematically examined using X10 objective and X40 objective. The number of helminths eggs from both slides were counted, recorded and the average egg count computed. The mean number of eggs per gram (EPG) was used to describe the infection intensity. and multiplied by a standard conversion factor of 24 (Cools *et al*., 2019; Gebreyesus *et al*., 2020). The WHO classification was used to classify the levels of infection (WHO, 1991) (Table1).

Table 1: Eggs per gram (EPG) estimates according to WHO guidelines

	Parasite intensity		
Intestinal parasite	**Light (epg)**	**Moderate (epg)**	**Heavy (epg)**
Ascaris lumbricoides	1-4,999	5,000-49,999	≥50,000
Trichuris trichiura	1-999	1,000-9,999	≥10,000
Hookworm	1-999	2,000-3,999	≥4,000
Schistosoma mansoni	1-99	100-399	≥400
Schistosoma japonicum	1-99	100-399	≥400

3.9.2 Formal-ether concentration method

Each stool sample was divided into two aliquots, one of which was stored in 80% ethanol and the other in 10% formalin. Formal-ether concentration method was applied to 392 samples as described (WHO, 1991; Cheesbrough, 2006). Using an applicator stick, the sample was mixed to evenly distribute the parasites. Approximately 3 ml of feces was strained through a two-layer folded surgical gauze placed on top of a funnel in a falcon tube (15ml) and topped up to 10 ml mark using formal saline. Diethyl-ether (3 ml) was added and the suspension homogenized and centrifuged at 2500 rpm for 10 min. Centrifugation produced four layers; diethyl-ether with dissolved fats at the top, a ring of fecal debris, formal saline layer and sediment with parasites concentrates at the bottom (**Figure 2**). The fatty debris plug was gently loosened and the tube inverted to drain off the supernatant while leaving the sediment for examination. The sediment was placed on a microscope slide along with a drop of Lugol's iodine, and preparation systematically examined under a microscope using X10 and X40 objective.

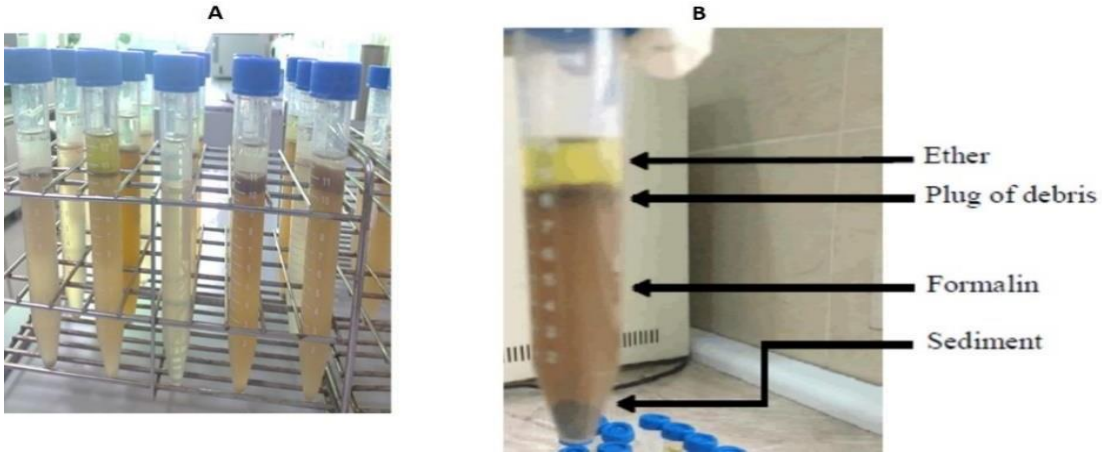

Figure 2: The formal-ether concentration method for detection of intestinal parasites.

Panel A shows the sieved fecal suspension after layering with formal-ether while Panel B shows the fractions following centrifugation.

3.9.3 Modified Ziehl-Neelsen (ZN) staining- for coccidian species

To detect *Cryptosporidium* species and other coccidian oocysts, a Modified Ziehl-Neelsen staining technique (WHO, 1991; Cheesbrough, 2006) was used. The formal-ether sediment was used to prepare smears, air dried overnight and stained. The staining reagents were made up of multiple stains; a carbol fuchsin solution as the primary stain, 3% Acid alcohol which acted as a decolorizer and malachite green (0.5% w/v) which served as a counterstain (Appendix VI). The smear was first fixed in absolute ethanol for 3 min and allowed to air dry then stained in carbol fuchsin for 15 min and excess stain washed off in running tap water. The smears were then stained in 3% acid alcohol for 15 sec and washed in tap water. Finally, the smear was stained with malachite green for 30 sec and any excess stain washed off in running tap water. The smear was left to dry and viewed under a microscope using oil immersion at x100 objective.

3.10 Quality control

For quality control, stool samples were examined in duplicate first by the principal investigator, and then verified by a qualified independent laboratory technician. In cases where the results differed, a consensus

was reached upon and the results were validated by a third senior experienced laboratory technologist. Positive archived samples were used as a standard reference.

3.11 Biosafety measures

The study team were trained on biosafety measures and standard operating procedures (SOPs) were followed during specimen collection and processing. Personal protective equipment (PPE) was used when handling contaminated materials, stool containers, equipment's and working surfaces. Decontamination of materials, equipment and surfaces was done using 10% sodium hypochlorite and 70% ethanol.

3.10 Disposal of waste materials and fecal samples

Disposal of waste was done in accordance to the KEMRI laboratory biosafety and biohazard waste disposal guidelines. Fecal samples and other biohazard waste were put in disposable red and yellow biosafety bags while sharps placed in a biohazard sharp box and incinerated at the KEMRI incinerator.

3.12 Data analysis

Data was entered into an Excel spreadsheet in Microsoft Office 2019 and reviewed for accuracy and completeness and finally analyzed using SPSS software (Version 20). Research participants characteristics were summarized using descriptive statistics; mean, standard deviations for continuous variables and proportions or percentages for categorical variables. Prevalence was defined as the percentage number of individuals positive for any of the infections divided by the number examined. Pearson's Chi-Square test was used for comparison of proportions and test for significance. A paired T-test was used to assess the reduction of the total egg count of soil transmitted helminths. Associated risk factors were analyzed, using univariate and multivariate analysis in a random effects logistic regression model and described as odd ratio (OR). In every analysis, a significance level of $p<0.05$ was used.

3.13 Ethical consideration and approvals

The study protocol was approved by the Kenyatta National Hospital-University of Nairobi Ethics and Research Committee (KNH-UON ERC) Ref. KNH-ERC/A/283, Protocol No. P79/02/2021 (Appendix IX). Approval was additionally given by the National Commission for Science, Technology and Innovation (NACOSTI) Ref. 986515, license No. NACOSTI/P/21/12517 (Appendix X). The county government of Narok, Department of Health and Sanitation Ref. DIR/NRKCNTY/MOH/60/110 granted permission to conduct this research (Appendix XI). Family/household heads signed informed consent before recruitment of participants (Appendix III and IV). Children aged 12-17years, were only included if they assented to the study (Appendix V). Confidentiality was maintained throughout the process. Refusal to take part in the research did not result in provision of substandard care by the clinicians. The results of the stool examination were communicated to both the study participant and the Narok county Director of Health.

CHAPTER FOUR: RESULTS

4.1 Study population demographics

4.1.1 Population demographics at baseline survey

A total of 92/483 (19.0%) consenting families residing in the villages in and around Oloisukut Conservancy were recruited. A total of 411 individuals provided a stool sample, out of these; 57.2% were females while 42.8% were males. The participants originated from the following villages; Itolish (18.5%), Ilookwaya (16.3%), Nkinye (10.7%), Kimintet (43.8%) and Pusanki (10.7%). The youngest participant was 2 years old while the oldest was 86 years old. The average age was 16 years (standard deviation (SD) ± 14 years, (95% CI, (14.80-17.71)). The male: female gender ratio was 1:1.3. There were significantly more females than males for the ≥15 years age category (p=0.024). There was an equal gender balance for pre-school children ≤4 years old. Primary school going children aged 5-14 years comprised the majority (46.2%), followed by secondary school children/adults ≥ 15 years (35%) and pre-school children ≤4 years (18.7%) (Table 2).

4.1.2 Population demographics at end line survey

A total of 131 individuals did not participate in the follow up survey; 62 of these were school children attending boarding schools, 17 participants had re-located to other areas while 52 individuals declined to participate. Although 280 individuals were recruited in the follow up survey, 35 individuals failed to provide a stool sample. The final analysis was thus done on 245 individuals in the endline survey (Figure 3). Of these, 42.9% were males and 57.1% were females. Within age categories, primary school going children (5-14 years) (42.4%) comprised the majority, followed by secondary school children/adults ≥ 15 years old (34.3%) and pre-school children, ≤4years old (23.3%) (Table 2).

Table 2: Population demographics

	Baseline survey (n=411)					**End line survey (n=245)**		
Characteristics	Gender		Total count (%)	χ^2	p-value	Gender		Total count (%)
Age categories (years)	Female (%)	Male (%)				Female (%)	Male (%)	
≤ 4	38 (49.3)	39 (50.7)	77 (100)			27 (47.4)	30 (52.6)	57 (100)
5-14	102 (53.7)	88 (46.3)	190 (100)			55 (52.9)	49 (47.1)	104 (100)
≥ 15	95 (66.0)	49 (34.0)	144 (100)	7.422	0.024*	58 (69.0)	26 (31.0)	84 (100)
Gender total	235 (57.2)	176 (42.8)	411 (100)			140 (57.1)	105 (42.9)	245 (100)
Villages								
Itolish	44 (57.9)	32 (42.1)	76 (100)			14 (51.9)	13 (48.1)	27 (100)
Ilookwaya	37 (55.2)	30 (44.8)	67 (100)			26 (61.9)	16 (38.1)	42 (100)
Nkinye	24 (54.5)	20 (45.5)	44 (100)			8 (44.4)	10 (55.6)	18 (100)
Pusanki	26 (59.1)	18 (40.1)	44 (100)			17 (58.6)	12 (41.4)	29 (100)
Kimintent	104 (57.8)	76 (42.2)	180 (100)			75 (58.1)	54 (41.9)	129 (100)

* $p < 0.05$

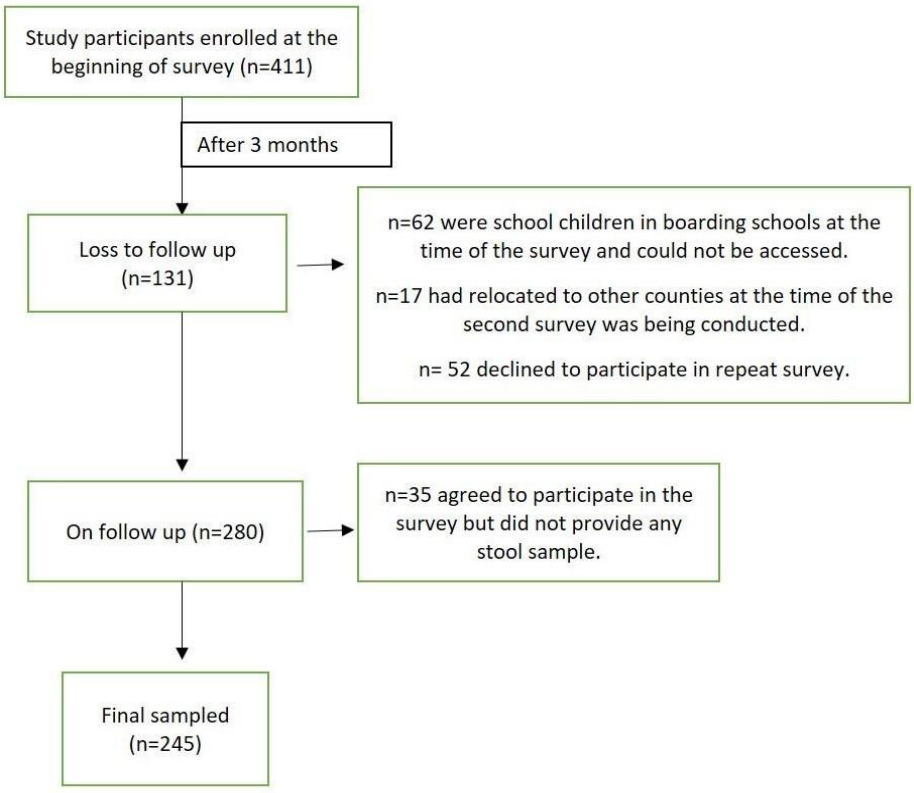

Figure 3: Schematic framework of recruited study participants

4.2 Overall prevalence of intestinal parasitic infection

Out of the 411 stool samples analyzed at baseline survey, 257 tested positive with at least one intestinal parasitic infection (IPI) giving an overall prevalence of 62.5 %. More males were infected with IPIs (65.3%) compared to females (60.4%); however, the difference was not significant (p= 0.31). IPI prevalence was higher (69%) among primary school-age children than it was among pre-school (64%) and that of secondary school children/adults (53%). These differences in infections between the three age groups were significantly different (p=0.015). Out of the 92/483 households sampled, (83.7%) had at least one family member infected with IPIs (Table3).

When pre-school children and secondary school children/adults were grouped and compared with primary school going children, IPIs was higher for primary school going children (69%) compared to the others (57%). The difference in infections between the two groups were significant (p=0.013). The prevalence of IPIs did not differ significantly among the five villages both at baseline (p=0.17) and at the end line survey (p=0.112) (Table3). Taking age as a continuous variable, the mean age of those with or without infections at baseline was 14.7 (SD ± 14 years, (95% CI, (14.88-17.80)) and 19 years (SD ± 16 years, (95% CI, (16.42-21.58)) respectively. Hence IPIs reduced with increasing age. The odds of infection (1.656) were higher among primary school going children compared to other age group categories (p=0.015). Although males had a higher odd of infection than females, the difference was not significant (p=0.39). The association between age and IPIs was significant (p=0.035) hence, the odds of infection reduced with increasing age (Table 4).

At end line survey, the prevalence of IPIs was 53.9% with a relative reduction rate of 13.8%. There was a reduction of prevalence of IPIs among the primary school going children from 68.9% at baseline to 59.6% in the follow up sample. IPIs prevalence among the pre-school children remained the same, while that for the secondary school children/adults ≥ 15 years old reduced from 53.5% at baseline

to 41.7% at the end line sampling. Differences in infections between the three age-groups was significant both at baseline (p=0.015) and end line survey (p=0.021) (Table 3).

Table 3: Overall prevalence of intestinal parasites by gender, age group categories and villages

	Baseline survey (n=411)					**End line survey (n=245)**				
Variable	Total count (%)	Uninfected (%)	Infected (%)	χ^2	p-value	Total count (%)	Uninfected (%)	Infected (%)	χ^2	p-value
Total sampled	411 (100)	154 (37.5)	257 (62.5)			245 (100)	113 (46.1)	132 (53.9)		
Gender										
Male	176 (100)	61 (34.7)	115 (65.3)	1.04	0.31	105 (100)	43 (41)	62 (59)	1.98	0.16
Female	235 (100)	93 (39.6)	142 (60.4)			140 (100)	70 (50)	70 (50)		
Age-group										
≤4 years	77 (100)	28 (36.4)	49 (63.6)	8.42	0.015*	55 (100)	21 (38.2)	34 (61.8)	7.75	0.021*
5-14 years	190 (100)	59 (31.1)	131 (68.9)			106 (100)	43 (40.6)	63 (59.4)		
≥ 15 years	144 (100)	67 (46.5)	77 (53.5)			84 (100)	49 (58.3)	35 (41.7)		
Total	411 (100)	154 (37.5)	257 (62.5)			245 (100)	113 (46.1)	132 (53.9)		
≤4 years and ≥ 15 years	221 (100)	95 (43)	126 (57)	6.21	0.013*	141 (100)	71 (50.4)	70 (49.6)	2.39	0.122
5-14 years	190 (100)	59 (31)	131 (69)			104 (100)	42 (40.4)	62 (59.6)		
Total	411 (100)	154 (37.5)	257 (62.5)			245 (100)	113 (46.1)	132 (53.9)		
Villages										
Itolish	76 (100)	36 (47.4)	40 (52.6)	6.41	0.170	27 (100)	10 (37)	17 (63)	7.49	0.112
Ilookwaya	67 (100)	23 (34.3)	44 (65.7)			42 (100)	23 (54.8)	19 (45.2)		
Nkinye	44 (100)	16 (36.4)	28 (63.6)			18 (100)	7 (38.9)	11 (61.1)		
Pusanki	44 (100)	11 (25)	33 (75)			29 (100)	8 (27.6)	21 (72.4)		
Kimintent	180 (100)	68 (37.8)	112 (62.2)			129 (100)	65 (50.4)	64 (49.6)		
Total	411 (100)	154 (37.5)	257 (62.5)			245 (100)	113 (46.1)	132 (53.9)		
Household level prevalence	92 (100)	15 (16.3)	77 (83.7)			72 (100)	10 (13.9)	62 (86.1)		

* $p < 0.05$

Table 4: Age and gender association with IPIs

	Baseline Survey			End line Survey		
Any IPIs	Odds Ratios	P-value	95% CI	Odds Ratio	P-value	95% CI
Age group	1.656	0.015	1.1017-2.4896	0.981	0.035*	0.9635-0.9987
Gender	1.198	0.388	0.7954-1.8039	1.344	0.266	0.7981-2.2643

*p<0.005

CI-Confidence interval

At baseline survey, 46.2% of participants had intestinal protozoa while 39.9 % had helminths. Preschool and primary school going children had more helminth (17% and 65.2%) than protozoan infections (12.7% and 53.6%) respectively. Secondary school children/adults had more protozoa (33.7%) than helminth infections (17.7%). Males had more helminths (46.3%) infections compared to protozoa (43.6%) while females had more protozoa infections (56.4%) compared to helminths (53.7%). The overall prevalence of protozoan infections remained high at 45% at end line survey while that of helminth infections reduced to 19.2%, with a relative reduction rate of 58.4% (Table 5).

Table 5: Distribution of IPIs within gender and age categories

	At baseline (n=411)			**At end line (after 3 months)** (n=245)		
Parasites	Total IPIs (%)	Protozoa (n=392) (%)	Helminths (%)	Total IPIs (%)	Protozoa (n=240) (%)	Helminths (%)
Total infected	257 (62.5)	181 (46.2)	164 (39.9)	132 (53.9)	108 (45%)	47 (19.2)
Male	115 (28)	79 (43.6)	76 (46.3)	62 (25.3)	47 (43.5)	22 (46.8)
Female	142 (34.5)	102 (56.4)	88 (53.7)	70 (28.6)	61 (56.5)	25 (53.2)
≤ 4 years	49 (63.6)	23 (12.7)	28 (17)	27 (49.1)	22 (20.4)	12 (25.5)
5-14 years	131 (68.9)	97 (53.6)	107 (65.2)	70 (66)	55 (50.9)	27 (57.4)
≥ 15 years	77 (53.5)	61 (33.7)	29 (17.7)	35 (41.7)	31 (28.7)	8 (17.0)

4.4 Intestinal parasites detected from stool samples

Eleven genera of intestinal parasites were observed at baseline survey (Table 6, Figure 6 & Figure 7) with an overall prevalence of IPIs at 62.5%. The intestinal helminths observed were *T. trichiura* (36.7%), followed by *A. lumbricoides* (5.6%), Hookworm (2.7 %), *H. nana* (1.2%), *Taenia* spp. (0.7%) and *S. stercolaris* (0.2 %). The intestinal protozoa observed were *E. histolytica/E. dispar/E. moshkovskii* (31.6%) and *G. lamblia* (9.7 %). Non-pathogenic protozoa observed were *E. coli* (24.6%), *I. buetschlii* (8.5%) and *C. mesnili* (1.0%).

Nine genera of intestinal parasites were observed at endline survey (Figure 4 & Figure 5). The overall prevalence of IPIs was 53.9%. Intestinal helminths observed were, *T. trichiura* (15.9%), *A. lumbricoides* (4.9%), and *Taenia* spp. (2.9%). Intestinal protozoa observed were *E. histolytica/E. dispar/E. moshkovskii* (31.8%), *G. lamblia* (13.5 %) and *Cryptosporidium* species

(0.4%). Non-pathogenic protozoa observed included E. coli (19.6%), *I. buetschlii* (6.5%) and *C. mesnili* (4.1%). No Hookworm, *H. nana* or *S. stercolaris* were observed at end line survey. However, one case of a new infection with *Cryptosporidium* spp. was detected.

There were no gender differences in infection for *E. histolytica/E. dispar/E. moshkovskii* (p=0.886), *G. lamblia* (p=0.101), *E. coli* and *I. buetschlii*. However, there were age group differences in infection for *E. histolytica/E. dispar/E. moshkovskii* (p=0.015), *E. coli* (p=0.018), *I. butschlii* (p=0.012), with primary school-going children being the most affected compared to other age groups. Age group differences were observed in infection with *G. lamblia* (p=0.003), with pre-school children bearing the most infection (18.2%) compared with the other age groups. There were no gender and age group differences in infection for C*hilomastix mesnili*.

There were no gender differences in *T. trichiura* infections. However, there were age group differences in infection for *T. trichiura* (p=0.001), with primary school children being most affected. Gender differences were observed for *A. lumbricoides* infection with males having a higher prevalence (8% males versus females at 4%). However, the differences were not significant (p=0.072). Significant differences were observed in infection for *A. lumbricoides* among age groups, with higher prevalence (13%) in pre-school children compared to primary school going children (6%) and ≥ 15 years (1%) (p=0.001). Hookworm infection was higher in males (4.5%) compared to females (1.3%) (p=0.042). However, there were no differences in age group for Hookworm infection. There was no gender or age group difference for infection with *H. nana, Taenia* spp. and *S. stercolaris*.

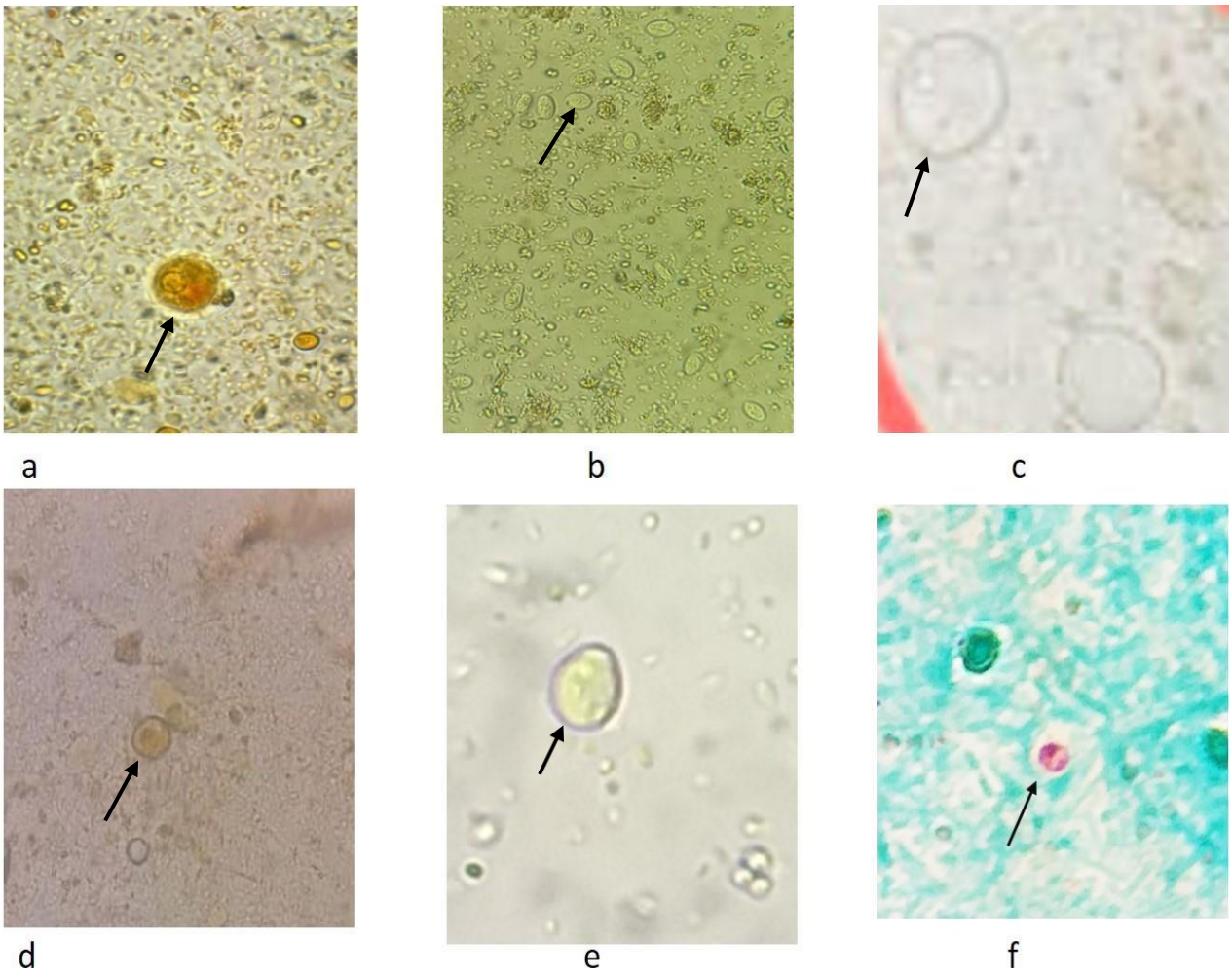

Figure 4 : Representative images of protozoan parasites (indicated by arrow) detected from stool

a). *Entamoeba histolytica* cyst **b).** *Giardia lamblia* cyst **c).** *Entamoeba coli* cyst **d).** *Iodamoeba buetschlii* cyst **e).** *Chilomastix mesnili* cyst *at* Magnification x400 **f).** Oocyst of *Cryptosporidium* spp. Magnification x1000**.**

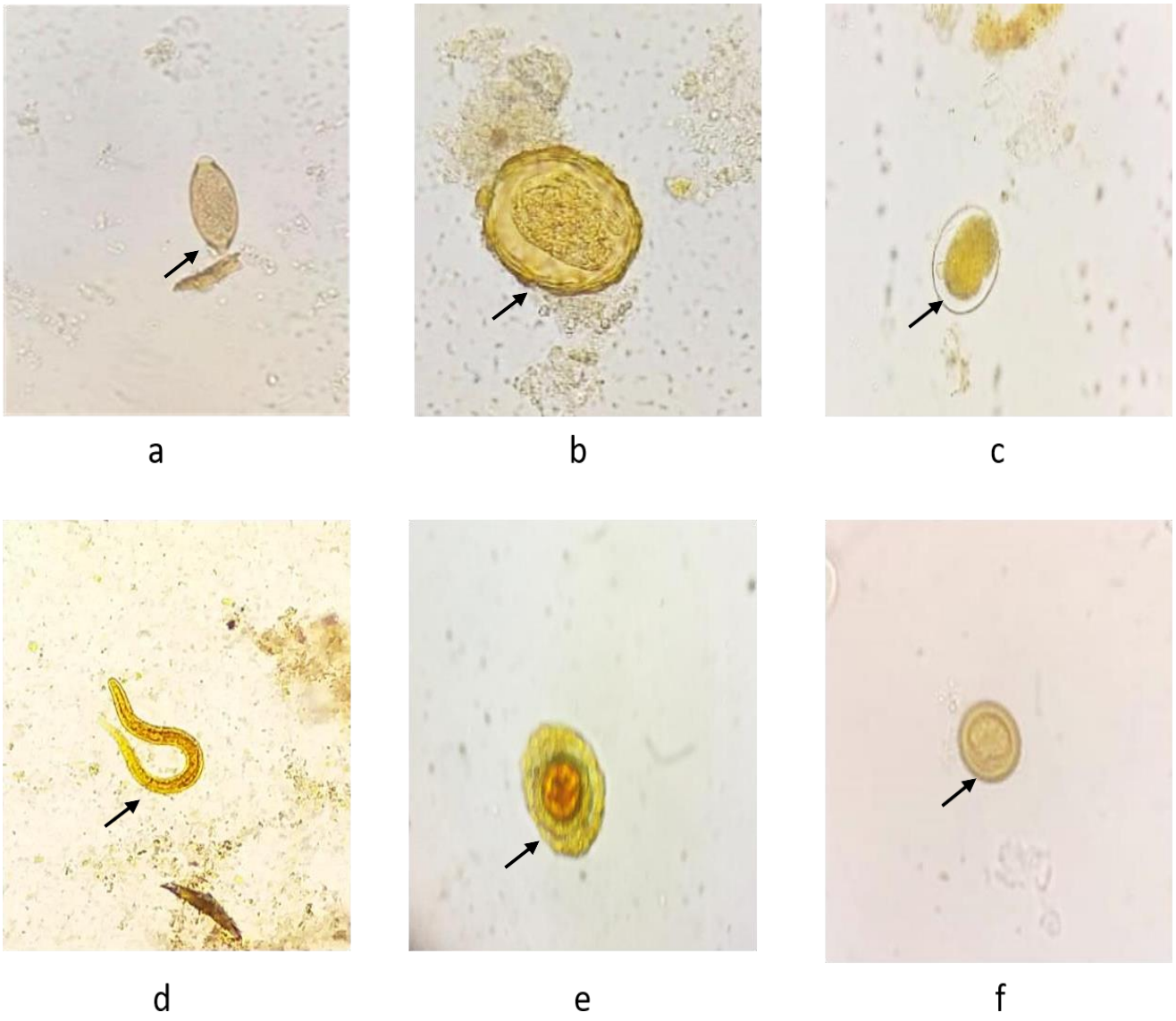

Figure 5: Representative images of helminth parasites (indicated by arrow) detected from stool

a) *Trichuris trichiura* egg **b)**. *Ascaris lumbricoides* egg **c)**. Hookworm spp. egg, **d).** rhabditiform larvae of *Strongyloides stercolaris,* **e).** *Hymenolepsis nana* egg **f)**. *Taenia* spp. egg. Magnification x400.

Table 6: Prevalence of intestinal parasites detected from stool within gender and age categories

	Baseline survey (n=411)								End line survey (n=245)
Intestinal parasites	Total count (%)	Male (%)	Female (%)	p-value	≤4 years (%)	5-14 years (%)	≥ 15years (%)	P-value	Total count (%)
Protozoa	181 (46.2)	79 (43.6)	102 (56.4)		23 (12.7)	97 (53.6)	69 (23.7)		108 (45.0)
E. histolytica/E. dispar/E. moshkovskii	130 (31.6)	55 (31.3)	75 (31.9)	0.886	14 (18.2)	69 (36.3)	47 (32.6)	0.015	78 (31.8)
G. lamblia	40 (9.7)	22 (12.5)	18 (7.7)	0.101	14 (18.2)	20 (10.5)	6 (4.2)	0.003	33 (13.5)
E. coli	101 (24.6)	43 (24.4)	58 (24.7)	0.954	10 (13)	56 (29.5)	35 (24.3)	0.018	48 (19.6)
I. buetschlii	35 (8.5)	15 (8.5)	20 (8.5)	0.997	0	20 (10.5)	15 (10.4)	0.012	16 (6.5)
C. mesnili	4 (1.0)	1 (0.6)	3 (1.3)	0.469	0	3 (1.6)	1 (0.7)	0.456	10 (4.1)
Cryptosporidium spp.	0	0	0		0	0	0		1 (0.4)
Helminths	164 (39.9)	76 (46.3)	88 (53.7)		28 (17.0)	107 (65.2)	29 (17.7)		49 (19.2)
T. trichiura	151 (36.7)	67 (38.1)	84 (35.7)	0.629	35 (45.5)	91 (47.9)	25 (17.4)	0.000	39 (15.9)
A. lumbricoides	23 (5.6)	14 (8.0)	9 (3.8)	0.072	10 (13.0)	12 (6.3)	1 (0.7)	0.001*	12 (4.9)
Hookworm	11 (2.7)	8 (4.6)	3 (1.3)	0.042*	2 (2.6)	7 (3.7)	2 (1.4)	0.436	0
H. nana	5 (1.2)	3 (1.7)	2 (0.9)	0.435	0	3 (1.58)	2 (1.4)	0.551	0
Taenia spp.	3 (0.7)	1 (0.6)	2 (0.9)	0.739	0	1 (0.53)	2 (1.4)	0.464	7 (2.9)
S. stercolaris	1 (0.2)	1 (0.6)	0	0.247	0	0	1 (0.7)	0.595	0
Total sampled	411 (100)	176 (100)	235 (100)		77 (100)	190 (100)	144 (100)		245 (100)
Total infected	257	115	142		49	131	77		132
Prevalence (%)	62.5	65.3	60.4		63.6	68.9	53.5		53.9

* $p < 0.05$

4.5: Prevalence of polyparasitism

Majority of participants had multiple infections (35.3%) compared to single infections (27.3%). The maximum number of parasites detected in a single individual stool sample was five. Single infections were more prevalent (27.3%) compared to double (18.5%), triple (10.5%), quadruple (5.4%) and penta (1%) infections. Polyparasitism was common between protozoa and helminths (21.4%) combined than protozoa co-infections (11.7%) or helminths co-infections (2.2%) (Appendix IX). More males (29%) had single infections compared to females (26%), however this difference was not significant (p=0.496).

Similarly, more males (36.4%) had multiple infections compared to females (34.5%). This difference was however not significant (p=0.691). Only four males (2.3%) had five multiple co-

infections. No significant differences were observed in single (p=0.487) or multiple (p=0.008) infections by age-group categories (Table 7). The most common co-infections were combinations of *E. histolytica/E. dispar/E. moshkovskii + E. coli* (72) followed by *E. histolytica/E. dispar/E. moshkovskii + E. coli + T. trichiura* (23) and *E. histolytica/E. dispar/E. moshkovskii, T. trichiura* (16) (Appendix VII).

Table 7: Polyparasitism of intestinal parasites by age categories, gender and parasites combination

Variable	Single infection		Multiple-parasitemia					
(n=411)	One (%)	p-value	Two (%)	Three (%)	Four (%)	Five (%)	Total (%)	P-value
Total positive	112 (27.3)		76 (18.5)	43 (10.5)	22 (5.4)	4 (1)	145 (35.3)	
Male	51 (29)	0.496	31 (17.6)	20 (11.4)	9 (5.1)	4 (2.3)	64 (36.4)	0.691
Female	61 (26)		45 (19.1)	23 (9.8)	13 (5.5)	0	81 (34.5)	
≤ 4 years	25 (32.5)	0.487	14 (18.2)	11 (14.3)	1 (1.3)	0	26 (33.8)	0.008
5-14 years	48 (25.3)		39 (20.5)	23 (12.1)	15 (7.9)	4 (2.1)	81 (42.6)	
≥ 15 years	39 (27.1)		23 (16)	9 (6.3)	6 (4.2)	0	38 (26.4)	

* $p < 0.05$

4.6 Effect of deworming on prevalence intestinal helminth infections

Intestinal helminths prevalence at baseline survey was 39.9%. At end line, helminth infections reduced to 19.2%, with a relative reduction rate of 58.4% (Table 5 above). Table 8 below shows prevalence of various STH. At baseline, frequency of *T. trichiura* infection was 36.7% which decreased to a prevalence of 15.9% at end line survey with a relative reduction rate of 56.7%. There was a marked reduction of *T. trichiura* infection with 34% of those positive at baseline remaining positive at the end point while 66% recovered after deworming (p=0.001). For *Ascaris lumbricoides*, the prevalence at baseline was 5.6% which reduced to a prevalence of 4.9% at end line with a relative reduction rate of 12.5%. All individuals infected with Hookworm (2.7%), *H. nana* (1.2%) and *S. stercolaris* (0.2%) did not have detectable ova/parasite in stool during the end point survey. Infection with *Taenia* spp. increased from 0.7% at base line to 2.9% at the end line survey. It was a significant (p=0.001) increase even though the prevalence of *Taenia* spp. was low.

Some individuals who had no infection at baseline acquired the infection at end line survey. Of the 245 individuals who submitted stool samples at both surveys, 90 (37%) individuals had no infection

while 155 (63%) had infection at baseline survey. Of the 90 negative participants, 51 (56%) remained negative after deworming while new infections were observed in 39 (43%) participants. Of the 155 who were infected at baseline, no parasitic infections were detected in 62 (40%), while 93 (60%) remained infected at end line survey (Table 9). New infections were mostly observed in *T. trichiura* and *A. lumbricoides* [9/245 (3.7%)] followed by *Taenia* spp.6/245 (2.5%) (Table 8).

Table 8: Effect of deworming on intestinal helminth infections (n=245)

Parasites	Baseline positive (%)	Endline Positive (%)	New infections (%)	Persistent infections (%)	Negative (%)	Total (%)	p-value
T. trichiura	151 (36.7)	39 (15.9)	9 (3.7)	30 (34.5)	57 (65.5)	87 (100)	0.001*
A. lumbricoides	23 (5.6)	12 (4.9)	9 (3.7)	3 (23.1)	10 (76.9)	13 (100)	
Hookworm	11 (2.7)	0	0	0	6 (100)	6 (100)	
H. nana	5 (1.2)	0	0	0	4 (100)	4 (100)	
Taenia spp.	3 (0.7)	7 (2.9)	6 (2.5)	1 (50)	1 (50)	2 (100)	0.001*
S. stercoralis	1 (0.2)	0	0	0	1 (100)	1 (100)	

*p<0.05

Table 9: Comparison of prevalence for individuals sampled both at baseline and endline survey

(n=245)	Baseline survey		Endline survey		
Characteristic	Total (%)	χ^2 (p-value)	Uninfected (%)	Infected (%)	χ^2(p-value)
Uninfected	90 (36.7)	0.012	51 (56.7)	39 (43.3)	0.012
Infected	155 (63.3)		62 (40)	93 (60)	
Total	245		113 (46.1)	132 (53.9)	

*p<0.05

4.7 Effect of deworming on intensity of soil transmitted helminths infections

The intensity of infection based on egg per gram (EPG) of feces is shown on Table 10. At baseline survey, all three species of STH had light (86.8%) to moderate (11.9%) infection intensity, and with only two cases (1.3%) of heavy intensity detected. The worm burden of *T. trichiura* and *A. lumbricoides* had a similar pattern with light infections (91.3% and 52.6%) being the most prevalent followed by moderate (7.9% and 42.1%) and one case each of heavy intensity respectively. However, all hookworm infections were light. At end line survey, STHs was light-moderate (76.5%-23.5%) with no cases of heavy intensity.

At baseline the mean intensity was highest for *A. lumbricoides* (13670 epg), followed by *T. trichiura* (870.5 epg) and then Hookworm (296 epg). Following deworming there was a decline in the intensity of infection, however this difference was not significant (Table 11).

Table 10: Distribution of STH mean intesity (epg) defining light, moderate and heavy infections

	At baseline (n=411)				At endline (after 3 months) (n=245)			
Intensity	All STH	Hookworm	*Ascaris*	*Trichuris*	All STH	Hookworm	*Ascaris*	*Trichuris*
Light	131 (86.8%)	6 (100%)	10 (52.6%)	115 (91.3%)	39 (76.5%)	0	6 (50%)	33 (84.6%)
Moderate	18 (11.9%)	0	8 (42.1%)	10 (7.9%)	12 (23.5%)	0	6 (50%)	6 (15.4%)
Heavy	2 (1.3%)	0	1 (5.3%)	1 (0.8%)	0	0	0	0
Total	151 (100%)	6 (100%)	19 (100%)	126(100%)	51 (100%)	0	12 (100%)	39 (100%)

Table 11: Reduction of total egg count

n=245	At baseline		At endline		p-value
STH	EPG	95% CI	EPG	95% CI	
Hookworm	296		0		
A. lumbricoides	13670	1782.6-25557.4	3163	-1016.9-7342.9	0.108
T. trichiura	870.5	-23.6-1784.6	245.9	50.8-440.9	0.104

* $p < 0.05$

CI: Confidence Interval, EPG: Eggs per gram

4.8 Univariate analysis of key risk factors from questionnaire survey

The risk factors associated with IPIs acquisition are shown on Table 12. Ninety-two questionnaires were administered to household heads. Out of these, 64 (69.6%) were mothers/female and 28 (30.4%) were fathers/male respondents. There was no association between the gender of the respondent and the possibility of a family member being infected with IPIs (p=0.729). The average age of the respondents was 37 years (SD ±14.96) with minimum age 16 years and maximum age 90 years. There were no differences in the mean age between families with at least one member infected and those with no member infected (p=0.96). Majority of the respondents (46.7%), did not have formal education, while the rest had either primary (26.1%) secondary (10.9%) or college/tertiary (16.3%) education. Although infection was highest among family household heads with no formal education (46.8%) and lowest among families whose household heads had a secondary level of education (13%), this was not

significantly different (p=0.337). Majority of respondents were self-employed farmers (53.3%) while the rest were either unemployed (33.7%) or had formal employment (13%). The employment status was not a risk factor to acquisition of IPIs (p=0.475). Most family household ranged between 5 to 10 (55.4%) in size, however, family size was not a risk factor of infection (p=0.984).

Majority of the houses were mud walled with earth floors (94.6%) and only 5.4% had concreate structures with cemented floors. There was no association between the housing structure and IPIs (p=0.880). Regarding toilet availability, majority of the households (57.6%) lacked a toilet within the homestead and practiced open defecation in the surrounding bushes. No association was found between availability of toilets and acquisition of IPIs (p=0.838). Raw meat was consumed by 17.4% of the respondents however no association was found between consumption of raw meat and acquisition of *Taenia* spp. (p=0.612). Drinking water was mainly collected from the river and dams (43.4%), while 19.6% households obtained their water from roof catchment rain water and 34.8 % from protected wells. Although most respondents (55.4%) did not treat water, no association was found between IPIs and water sources (p=0.698). Majority of adults (90.2%) compared to 56.5% of children wore shoes, but no significant difference in Hookworm infection was observed among those who wore shoes and those who did not (p=0.819). Only 17.4% of the respondents had never been dewormed, while 28.3% regularly dewormed and 54.3% only dewormed occasionally. Among the children, 7.6% had never dewormed, 28.3% dewormed regularly while 64.1% dewormed occasionally. Albendazole/mebendazole was the most common used deworming drug in 67.4% of the respondents followed by traditional herbs, however the deworming method was not associated with IPIs (p=0.883). Fingernail hygiene was practised by almost all (98.9%), however it was not significantly associated with IPIs. (p=0.657).

Table 12: Univariate analysis of key risk factors associated with IPIs

Characteristic (n=92)	Variable	No. of respondents (%)	**Infected (%)**	**Uninfected (%)**	**Odds ratio**	**P-value**
Total		**92 (100)**	**77 (100)**	**15 (100)**		
Gender	Male	28 (30.4)	24 (31.2)	4 (26.7)	1.084	0.729
	Female	64 (69.6	53 (68.8)	11 (73.3)		
level of education	Primary	24 (26.1)	18 (23.4)	6 (40)	1.158	0.337
	Secondary	10 (10.9)	10 (13)	0		
	College	15 (16.3)	13 (16.9)	2 (13.3)		
	Never	43 (46.7)	36 (46.8)	7 (46.7)		
Occupation of household head	Employed	12 (13.0)	10 (13)	2 (13.3)	1.326	0.475
	Self-employed farmer	49 (53.3)	43 (55.8)	6 (40)		
	Unemployed	31 (33.7)	24 (31.2)	7 (46.7)		
Family size	<5	20 (21.7)	17 (22.1)	3 (20)	0.906	0.984
	5 – 10	51 (55.4)	43 (55.8)	8 (53.3)		
	10-20	16 (17.4))	13 (16.9)	3 (20)		
	>20	5 (5.4)	4 (5.2)	1 (6.7)		
Type of house	Mud wall earth floor	85 (92.4)	71 (92.2)	14 (93.3)	1.141	0.880
	Concrete	7 (7.6)	6 (7.8)	1 (6.7)		
Availability of toilet	Yes	39 (42.4)	33 (42.9)	6 (40)	0.884	0.838
	No	53 (57.6)	44 (57.1)	9 (60)		
	No	9 (9.8)	8 (10.4)	1 (6.7)		
Deworming method used	None	15 (16.3)	13 (16.9)	2 (13.3)	0.913	0.883
	Traditional methods	15 (16.3)	12 (15.6)	3 (20)		
	Albendazole/Mebendazole	62 (67.4)	52 (67.5)	10 (66.7)		
Principal water source	Protected well	32 (34.8)	28 (36.4)	4 (26.7)		0.698
	Rain water	18 (19.6)	15 (19.5)	3 (20)		
	water from natural sources	40 (43.5)	32 (41.6)	8 (53.3)		
Water treatment	Yes	41 (44.6)	30 (39)	11 (73.3)		0.014
	No	51 (55.4)	47 (61)	4 (26.7)		
Finger nails hygiene	Yes	91 (98.9)	76 (98.7)	15 (100)		0.657
	No	1 (1.1)	1 (1.3)	0		
Hookworm spp only						
Shoes wearing habits	Yes	83 (90.2)	10 (90.9)	14 (93.3)	0.053	0.819
	No	9 (9.8)	1 (9.1)	1(6.7)		
Taenia spp only						
Consumption of raw meat.	Yes	16 (17.4)	1 (33.3)	3 (20)	0.257	0.612
	No	76 (82.6)	2 (66.7)	12 (80)		

*p<0.05

4.9 Multivariate analysis of key risk factors from questionnaire survey

Multivariate analysis was done to elucidate the association of various risk factors variables and possible infection (Table 13). None of the factors were significantly linked with IPIs. The mixed effects regression model for the effect of age on *T. trichiura, A. lumbricoides,* Hookworm, *Taenia* spp., *H. nana* eggs concentration in stool controlled for gender, education and village. None of the risk factors were significantly different even in the models for the other organisms/STHs.

Table 13: Multivariate analysis of key risk factors associated with IPIs

Characteristic	**Odd Ratio**	**P-value**
Gender	1.0843	0.909
Age of respondent	1.006	0.802
Level of education	1.158	0.651
Family size	0.906	0.800
Occupation of household head	1.326	0.607
Type of house	1.141	0.912
Availability of toilet	0.884	0.861
Shoes wearing habits	0.609	0.662
Deworming method used	0.913	0.823
Constant	6.628	0.240

*$p<0.05$

CHAPTER FIVE: DISCUSSION, CONCLUSION AND RECOMMEDATION

5.1 Discussion

5.1.1 Prevalence of Intestinal Parasitic Infections (IPIs)

IPIs still have a detrimental effect on community health. Mass drug administration (MDA) at regular intervals is advised by the World Health Organization. to guarantee that infection transmission levels are lowered (Clarke *et al*., 2018). This study provided a comprehensive assessment on prevalence of IPIs and their associated risk factors at a community level. IPIs were detected at a prevalence of 62.5% which was lower than the 73.2% prevalence from previous studies conducted in rural communities of West Malaysia (Ngui *et al*., 2011). It was comparable with studies in other developing countries; 62.3% from Ethiopia, 64.7% from West Africa and 68% from Bondo Kenya (Thiong'o *et al*., 2001; Liao *et al*., 2016). The prevalence was greater than the country's average for IPIs in other regions in Kenya; 41.1% from Kisii by Nyarango *et al*., (2008), 15.7% from Nairobi by Kamau *et al*., (2012), 50.9% from Baringo by Kipyegen *et al*., (2013), 25.6% from Nairobi by Mbae *et al*., (2013), 24.7% from Kisii by Rop *et al*., (2016), 46.5% from Eldoret hospital by Ngeiywa *et al*., (2018) and 43.0% from Embu by *Kamonge et al*., (2020). Additionally, it was higher than most developing countries; 57.88% from Northeast Ethiopia, 57.5% from Malaysia and 26.4% from Cameroon (Rajoo *et al*., 2017; Sitotaw *et al*., 2019; Igore *et al*., 2020) Previous studies done in Nakuru town Kenya had an overall prevalence of 17.3% (STH- 1.2% and protozoan parasites 41.7%) (Chege *et al*., 2020) The variations in prevalence could be explained by disparities in the geographical locations, social demographics of the study participants, people's socio-economic situation, immune status, hygiene education and behavior, access to hygienic facilities and local endemicity. The high prevalence of IPIs in this study indicates this community lives in a parasite-filled environment that is highly polluted.

IPI infection rates among male participants (65%) were greater than those among female individuals (60%) but the difference was not significant. This finding was consistent with results from

earlier studies that found no appreciable differences of IPIs within gender categories (Wegayehu *et al*., 2013; Mekonnen *et al*., 2016; Tegen and Damtie, 2021). The equal chance of IPIs between both genders could be due to the narrowing of gender roles in the conservancy.

According to studies by WHO, (2011), school-aged children (SAC) (5–14 years old) who reside in high endemic areas carry the largest burden of these diseases. The high incidence of IPIs among school-going children in this study is consistent with those data. SAC are more susceptible to environmental contamination, especially while playing, eating, bathing in or drinking untreated water (Korkes *et al*., 2009). Children are particularly vulnerable to intestinal parasites because they have more complex nutritional needs and less developed immunity. They are in an active stage of growth and habitually play in contaminated soil without regard to good sanitary behavior. In addition, they also spend long hours in school environment characterized by overcrowding, lack of handwashing facilities and poor hygiene practices (Masaku *et al*., 2020). The high rate of IPIs among the primary school children may be due to chronic endemicity over time or high transmissions rates in this age group. School aged children are thus important reservoirs for IPIs and therefore maintain transmission (Korkes *et al*., 2009).

The current public health control program for STH in Kenya is the National school-based deworming program (NSBD) and mainly targets school aged children. The gains of school-based deworming program have previously been reported to result in marked reduction in prevalence and intensity of STH (Okoyo *et al.,* 2020). Additionally, it has been demonstrated that school-based deworming programs benefit untreated populations within and close to schools where treatment has been mounted (Masaku *et al*., 2017). Despite being enrolled in the NSBD program, there is still a significant frequency of STH among school-age children, necessitating continuous MDA to reduce the burden of IPIs within this age group.

This study revealed 64% of IPIs were among the pre-school children while 53% of participants ≥15 years old were infected. The reported prevalence was higher than the level considered a public health

problem (defined by Giardina *et al*., (2019) as prevalence below 1%) thus significant. The high prevalence could be as a result of untreated, protracted infection exposure. It has been established that children between the ages of 3 and 5 defined as pre-school age children (PSAC), are susceptible to intestinal diseases. In previous studies, this group has been excluded not only in disease surveillance, but also in control programs for reasons that they carry insignificant burdens of intestinal infections (Masaku *et al*., 2020). Njenga *et al*., (2011) reported that majority of control programs for STH and schistosome infections often targeted only the school-aged children, excluding other community members who are potentially infected and could serve as a reservoir for transmission.

Previously, other studies have reported that pre-school children bear intestinal infections particularly STHs at similar levels as primary school going children and require consideration in MDA programs (Davis *et al*., 2014; Gichuki *et al*., 2019). Pre-school and secondary school going children/adult populations in the Oloisukut community were infected with intestinal parasites and may be a continuing source of infection for dewormed primary school children, therefore impeding the success of the control program. Therefore, continued scale up of school-based deworming program with focus on only primary school going children may leave pre-school children, secondary school going children and adults in the community unprotected. In order to control the global disease burden of IPIs, there is a critical need to review the school-based deworming program into a community-based approach. Recently, deworming programs have begun including pre-school children in both treatment and control programs for improved outcome. However, the NSBD is yet to overcome logistical challenges, to ensure that all pre-school children participate in deworming programs (Musuva *et al*., 2017; Riaz *et al*., 2020).

Compared to protozoa, intestinal helminths prevalence was lower in this study. Other investigations, including ones carried out in areas of Bomet and Nakuru in Kenya, have revealed a low prevalence of intestinal helminths compared to protozoa (Too *et al*., 2017; Chege *et al*., 2020). Similarly, in West Africa, more protozoa infections were observed compared to helminths infections (Liao *et al*.,

2016). In contrast, research in West Malaysia found that STH were noticeably more prevalent than protozoa infections (Ngui *et al*., 2011). The low prevalence of intestinal helminths compared to protozoa could be due mitigating factors such as school-based deworming program in the area which have been mounted to control of STH resulting in low prevalence. Protozoa cysts or trophozoites once excreted from the body are highly infective unlike helminths eggs which take long for development to occur before getting to their infective form. Thus, infection is likely to occur more commonly for *E. histolytica* and if untreated, infected people can spread protozoa infections indefinitely. Given that the disease is spread fecal-orally by food and water, the high prevalence of protozoa may be caused by inadequate hygiene (Cheesbrough, 2006). Interestingly, in many African countries, compared to STHs, intestinal protozoa seem to generate far less interest. There is currently no control program targeting intestinal protozoa in Kenya since control programs have targeted STH and schistosomiasis control. It is therefore important to integrate control of protozoa infections into MDA programs given their burden and significant morbidities associated with these infections.

Pre-school and primary school going children had more helminths compared to protozoa. Children within this age group are more likely to engage in outdoor activities and handle feces-contaminated items, which exposes them to risk of parasitic infections (Obala *et al*., 2013). Adolescents and adults had more protozoa infections than helminth infections. This group has less interaction with soil unlike children who play regularly with contaminated soil (Gelaw *et al*., 2013).

Entamoeba histolytica/E. dispar/E. moshkovskii was the most prevalent intestinal parasites detected in this study followed by *G. lamblia*. Similarly, in Murang'a, Kenya, *E. histolytica* was the most common intestinal protozoa among school children (Kamande *et al*., 2015). This was as opposed to research by Ngui *et al*., (2011) and Kotian *et al*., (2014) which stated that *G. lamblia* was the most prevalent protozoa. High community infections involving *E. histolytica* and *G. lamblia* pose serious public health concerns due to their pathogenic nature. Even if WASH programs were to improve, it still

remains possible to get reinfected with protozoa if not treated. *G. lamblia* infection was mostly prevalent in pre-school children and it was in agreement with studies by Kotian *et al*., (2014). Infections are acquired early during infancy with high prevalence of about 30% reported in children below 10 years of age (Laishram *et al*., 2012). Water exposure is significant risk factor for giardiasis. Giardiasis outbreaks have been caused by human waste and giardia cysts that have been isolated from water supplies contaminating the drinking water supply (Savioli *et al*., 2006; Kotian *et al*., 2014).

T. trichiura was the most common STH found in this study followed by *A. lumbricoides*, and hookworm. These outcomes agreed with research done in Malaysia by (Ngui *et al*., 2011), but were contrary to the typical infection pattern of *Ascaris*-Hookworm-*Trichuris* observed from studies in many African communities and the global data (de Silva *et al*., 2003; Hotez *et al*., 2008). The high infection prevalence of *T. trichiura* could be attributed to mebendazole which is ineffective in clearing the infection notwithstanding the many years use in MDA programs (Ahmed *et al*., 2011; Ngui *et al*., 2011; Masaku *et al*., 2020; Okoyo *et al*., 2020). Albendazole or mebendazole have been shown to be ineffective for treating trichuriasis. However, both medications are effective against ascariasis (Knopp *et al*., 2010). It has been hypothesized that *T. trichiura* may be resistant to albendazole and mebendazole (Norhayati *et al*., 1997). Although there is no proof of drug resistance, more study is required to support this claim. The use of albendazole and ivermectin drug combinations should be considered as an alternative for treatment of infections involving *T. trichiura* (Knopp *et al*., 2010).

The predominance of *T. trichiura* could in part also be credited to the geographical location of the research area which is an interface of wildlife and domestic animals. Climate around Oloisukut Conservancy is warm and moist with enriched clay soils (Mpario, 2011; Oloisukut, 2022). These conditions create an environment that is conducive to growth, survival, and transmission of *T. trichiura*. The soil condition is ideal for growth and spread of helminths eggs, and they may also retain the eggs. Additionally, eggs of *T. trichiura* are resistant to inactivation, can withstand harsh conditions and can

survive a period of dormancy up to 11 years under ideal conditions (Else *et al*., 2020). Further studies on the soil properties and composition in relation to development of *T. trichiura* parasite are recommended in the area. School children (5-14 years old) were more infected with *T. trichiura*, while higher prevalence of *A. lumbricoides* was seen in pre-school children. This finding was consistent with earlier research by (Okoyo *et al*., 2020) higher prevalence of *T. trichiura* among those aged 5-14 years while higher prevalence of *A. lumbricoides* were seen in younger children (>5 years).

In this study, hookworm infections were found, though at a low prevalence that was consistent with infections reported in several investigations in Kenya (Kiiti *et al*., 2020; Masaku *et al*., 2020). This indicates that the environment may be less contaminated by infectious larvae. Hookworm filarial larvae have a shortened lifespan (3–10 days) resulting to slower infection rates unlike *A. lumbricoides* eggs that takes several months to mature. Hookworm infections were prevalent in all age groups, in contrast with previous studies from Mwea that associated Hookworm infections with older age groups (16-19 years old) (Kihara *et al*., 2007**)**. This study findings contradict the hypothesis that human activity outside the household increases with age and so does the risk of acquiring Hookworm infection (Mekonnen *et al*., 2016). The non-loamy soil quality in the study area, which is unfavorable for the growth of Hookworm larvae, could also attribute to the low prevalence of hookworm infections (Ahmed *et al*., 2011). The majority of the study's adult participants wore shoes most of time which has been linked with low prevalence of hookworm elsewhere (Gebreyesus *et al*., 2020).

Prevalence of *Taenia* spp. was higher than what had been observed previously in western Kenya (Wardrop *et al*., 2015). These findings were consistent with previous studies from endemic regions of East, Southeast and South Asia (Eichenberger *et al*., 2020), though less than reported prevalence in India (Lateef *et al*., 2020). The presence of human taeniasis in this study confirms zoonotic existence in this study area. *Taenia* spp. infection is acquired through ingestion of undercooked meat infected with larval stages of the tapeworms. Human carriers of *Taenia* spp. tapeworms can transmit infection via shedding

of eggs in feces, which are ingested by the intermediate host (cattle for *T. saginata* and pigs for *T. solium)* and subsequently develop into larvae (cysticerci). Transmission of taeniasis is associated with poor sanitation, lack or inadequate meat inspection practices and fecally polluted environment (Cheesbrough, 2006; Wardrop *et al*., 2015). One significant sociocultural aspect of the Oloisukut reserve is the rearing of cattle and the consumption of beef. Based on questionnaire responses, consumption of under cooked meat ("soft meat") was common among the study's subjects. Beef was the most popular available source of animal protein in the conservancy suggesting that Taenia infection was due to *T. saginata*. Despite most countries including Kenya having documented cases of *T. saginata*, human taeniosis continues to be widely ignored (Dermauw *et al*., 2018). Appropriate controls for *T. saginata* transmission as well as epidemiological research to monitor *Taenia* infection are required.

5.1.2 Effect of deworming on declining prevalence of STH

STH prevalence reduced from 39.9% at baseline to 19.2% at end line, with a relative reduction rate of 58.4%. This result was consistent with earlier research by Okoyo *et al*., (2016) on NSBD in Kenya. Worm burden of STH was predominantly light in intensity followed by moderate and with two cases of heavy infections at baseline. At endline, the worm burden reduced with majority of infections being light-moderate. This is consistent with previous monitoring and evaluation study on NSBD in Kenya by Okoyo *et al*., (2020) that reported a decline in STH infections after MDA. These results underpin preventive chemotherapy through community-based MDA can decrease the frequency and severity of STH infections.

Reduction of Hookworm spp. was well pronounced to zero compared to other intestinal parasites, suggesting that deworming has a greater effect on Hookworm than the other IPIs. There were different declining rates in the various STH species and perhaps indicate their varying response to the mebendazole drugs. Previous studies have evaluated WHO essential drugs; albendazole, mebendazole, levamisole, and pyrantel pamoate for treating STH. They reported a high cure rate of albendazole, mebendazole, and

pyrantel pamoate against *A. lumbricoides* while only albendazole was effective against Hookworm. Both albendazole and mebendazole had low efficacy (28% and 36% cure rate) against *T. trichiura* respectively (Keiser and Utzinger, 2008). Similarly, (Moser et al., 2017) reported that all medications were extremely effective against *A. lumbricoides*. Albendazole outperformed all other drugs, whereas mebendazole had the best cure rate for *T. trichiura*. Using albendazole or mebendazole combined with ivermectin was effective against *T. trichiura* and had better therapeutic impact in control programs against STHs and *S. stercoralis* (Knopp *et al*., 2010).

While deworming resulted in decline of infections, high rate of re-infections (43%) remained a problem in this study. Re-infection following chemotherapy has previously been shown to occur (Okoyo *et al*., 2016). This could be attributed to community members (pre-school children and the adults) not included in the school-based deworming programs (Truscott *et al*.,2014) . *T. trichiura* and *A. lumbricoides* showed the highest rates of reinfection. This contradicts with previous studies that reported *A.lumbricoides* had higher levels of re-infections followed by *T. trichiura* and Hookworms (Okoyo e*t al*., 2016). Similarly, (Jia *et al*., 2012) observed re-infections caused by *A. lumbricoides* and *T. trichiura* occurred rapidly compared to other species. This finding implies that in the long run, deworming program alone is not sustainable since it is unable to protect treated individuals from re-infection.

Previous studies have suggested that the most effective method of preventing re-infections and drug resistance is preventative chemotherapy combined with the management of relevant risk factors (Okoyo *et al*., 2021a). It has been shown that re-infections are likely to occur as early as within two months after deworming with almost half of the treated population re-infected by month four post treatment and by six months, infections intensity back at pre-treatment levels (Norhayati *et al*., 1997; Hesham Al-Mekhlafi *et al*., 2008). Albonico *et al*., (2002), similarly noted that intensity of *T. trichiura* and *A. lumbricoides* by six months were the same as intensity during pre-treatment survey. In order to lower the rate of re-infections, it is strongly advised that the control and treatment programs undergo a

thorough evaluation. Absence of toilets increases the likelihood of STH re-infection by contaminating the household surroundings with infected excrement. STHs' eggs and larvae can persist in the soil for a very long time and act as a source of reinfection (Gichuki *et al*., 2019).Hence, proper sanitation and regular treatment (which aids in disrupting the cycle of helminth transmission) is critical (Ahmed *et al*., 2011).

A mathematical model carried out by (Okoyo *et al*., 2021b) to predict the elimination period of STH revealed that using MDA alone in 3-monthly plan would be effective in elimination of STH. However, using MDA and WASH was most effective and would give an optimal (95%) coverage level. For maximum benefit, there is need to integrate MDA with health education especially for behavior change and implementation of WASH.

5.1.3 Risk factors associated with intestinal parasites

Age group category was the only risk factor strongly linked to IPIs with school children being the most affected compared to other groups in this study. This finding was in keeping with studies from earlier investigations by (Njambi *et al*., 2020; Tegen and Damtie, 2021). In this current study, none of the risk factors assessed were associated with IPIs. Our findings were contrary to previous studies that reported not wearing shoes, types of latrines, indiscriminate defecation, indiscriminate swimming in rivers, hand washing practices, washing fruits before consumption, types of domestic animals kept in homes, large family size, goat rearing, earthen floor, consumption of raw vegetables, untrimmed finger nails, sources of water for drinking, drinking untreated water were significant factors associated with intestinal parasites (Ahmed *et al*., 2011; Kamonge *et al*., 2019; Mwandawiro *et al*., 2019; Chege *et al*., 2020; Igore *et al*., 2020; Njambi *et al*., 2020). The sample size, study period, and stool examination techniques may have contributed to the variations in this observation.

5.2 Conclusion

1. A significant high prevalence of IPIs was observed among the community living within and around Oloisukut Conservancy in Narok County, Kenya.
2. *T. trichiura* was the most prevalent intestinal helminths while *E. histolytica/E. dispar/E. moshkovskii* was the most common intestinal protozoa.
3. Presence of *Taenia* spp. in the research area confirmed the presence of zoonotic infections.
4. Infection rates were higher for protozoa compared to helminths. Most infections were reported among primary school going children.
5. Polyparasitism was more common than single infections.
6. Age was a risk factor linked with IPIs. An appreciable decline in prevalence of STH three months after deworming was observed, however, this reduction level was still above the WHO recommended threshold for MDA control.

5.4 Recommendation

1. Based on the high prevalence of intestinal protozoan infections, this study recommends for the review of the national guidelines on MDA regimen and to also integrate preventive chemotherapy for intestinal protozoa in Narok county.
2. MDA for treatment of STH should include all persons in the community in order to eliminate potential reservoirs and interrupt transmission of infection.
3. Meat inspection and health education should be emphasized to reduce the risk of infection with zoonotic pathogens such as *Taenia saginata*.
4. Further studies to determine drivers of IPIs particularly *T. trichiura* which was the most common intestinal parasite are recommended. This includes and is not limited to the ecological studies on the soil properties in relation to development of *T. trichiura* in the area.

5. Further studies on the predictors and effects of polyparasitism in the study area should be initiated.
6. Implementation of WASH, health education and utilizing combined antiparasitic drugs to complement preventive chemotherapy can further accelerate reduction of IPIs transmission in the community.
7. Community-based deworming program can improve efficiency and effectiveness of MDAs.

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APPENDICES

APPENDIX I : DATA COLLECTION TOOLS-QUESTIONNAIRE ENGLISH -MAA LANGUAGE

SECTION A: Socio demographic data

1. 1. Serial Number Age in years: **(ilarin aja iyata)** Gender: Male **(ole)** Female **(enkito)**
2. level of education? **(kai intabayie enkisoma)**

   (a) Primary b) Secondary (c) College/University (e) Never
3. Status of school attendance? **(nkardasini elotunoto esukul)**

   (a) Graduated **(enkidipara enkisoma)** (b) Attending**(embaunoro)** (c) Dropped **(etupukuo)**
4. Occupation of household head? **(kaa siai iyasita)**
5. a) Employed farmer **(aigeroki)** (c) Self-employed farmer **(aigero keon)** (d)Unemployed **(meera esiai)**
6. Compound religion: **(ira orkanisai anaa?)**

   (a) Christian **(lairukok)** (b) Muslim **(silamu)** **(**c) Hindu (d) Other **(ngulie)**
7. What is the size of your family? **(Kebaa ngerai ono)** (a) <5 (b) 5-7 c) 8-10 (d) >10
8. In which type of house do you live? **(Kengaji naiyaa imanyanya)**

   (a) Concrete **(esimiti)** (b) Mud wall, earth floor **(engulughoni enkok)** (c) Mud wall, cement floor **(engulughoni esimiti engok)** (d) Wood, cement floor **(mbaon esimiti engok)** (e) Wood, earth floor (**mbaon enkok)**

SECTION B: Risks associated factors

1. Does your home have a toilet or latrine?**(Eriatata nchoo tiang)** (a) Yes **(eesepa)** (b) No **(meesepa)**
2. Type of toilet type at home? **(iyata choo?)**

   (a) Private **(kerii nchooi nkangtie)** (b) Communal **(keno oltongana pookin)**
3. How do you dispose human feaces **(kaipighiphighi oleirerio eni orooro)?**

   (a) Open dump? **(epikipiki ewue neisudoro)** (b)Bury **(inoghaagha)** (c) Burn **(ipejepheje)**
4. Where do you defecate at night? (Kaiphoguo choo kewarie)

   (a) Open field **(ewei neisiaja)** (b) Latrine (nchooi) (c)Bushes (osero)
5. Do you clean your toilet/latrine? **(Isujisuji nchooi)** (a) Yes **(eesepa)** (b) No **(meesepa)**
6. Do you wash hands with soap after defecating? **(Isujusuju ngaek tosabuni)**

   (a) Yes **(eesepa)** (b) No **(meesepa)**
7. Do you wash hands with soap before you eat? **(intuku oshi enkaik inono eton etu iinos endaa?**

   (a) Yes **(eesepa)** (b) No **(meesepa)**
8. Do you wash fruits and vegetables before eating? **(Isoji suji irmatunda omboga etuinyanya)**

   (a) Yes **(eesepa)** (b) No **(meesepa)**
9. Do you eat raw meat? **(inyanya ngiri naajon)** (a) Yes **(eesepa)** (b) No **(meesepa)**
10. Principal source of drinking water:**(kai oshi eingwaa enkare niokitoto?)**

(a) Unprotected well **(Meara eriphoro)** (b) protected well **(eriphoro sidai)** **(c)** rain water **(enkare enjan)** (d) water from natural sites **(enkare olchoro)**

11. Do you cut your fingernails? **(Idungudungu laisoro)** (a) Yes **(eesepa)** (b) No **(meesepa)**

12. Do you wear shoes all the time? **(inchop oshi inamuka pooki saa)** (a) Yes **(eesepa)** (b)No **(meesepa)**

13. How often do you deworm? **(Kajo inonaghighi ntoghiri olnjani lolkuto)**

(a) Never **(akata)** (b) Sometimes **(ngaraitin)** (c) Always **(enkara pokin)**

14. When did you last deworm? **(kanu ibayeye njoo ntoghiri olanjani lolkuto)**

(a) 3 months ago (b) 6 months (c) Never **(akata)**

15. Do you have access to a health facility? **(iyatata sipitalini)** (a) Yes **(eesepa)** (b)No (**meesepa**)

16. How far is the hospital, health Center, dispensary? **(kebaa elakwani eina sipitali)** (distance in km or time)

APPENDIX II: DATA COLLECTION TOOLS: KISWAHILI TRANSLATION

Kiambatisho: Zana za Ukusanyaji wa Takwimu-Hojaji ya lugha ya kiswahili

SEHEMU YA A: Takwimu za idadi ya watu

1. Nambari ya serial: Umri katika miaka: Jinsia: Kiume Mwanamke

2. Elimu?

(a) Msingi b) Sekondari (c) Chuo Kikuu (e) Kamwe

3. Hali ya mahudhurio ya shule?

(a) Walihitimu (b) Kuhudhuria (c) Kuanguka

4. Kazi ya mkuu wa kaya?

a) Mkulima aliyeajiriwa (c) Mkulima aliyejiajiri Asiye na kazi

5. Dini ya kiwanja:

(a) Mkristo (b) Mwislamu (c) Mhindu (d) Mwingine

6. Familia yako ina ukubwa gani? (a) <5 (b) 5-7 c) 8-10 (d)> 10

7. Je! Unaishi katika nyumba gani? (a) Zege (b) Ukuta wa matope, sakafu ya ardhi (c) Ukuta wa matope, sakafu ya saruji (d) Mbao, sakafu ya saruji (e) Mbao, ardhi sakafu

SEHEMU B: Hatari sababu zinazohusiana

1. Je! Una choo / choo nyumbani? (a) Ndio (b) Hapana

2. Aina ya choo nyumbani? (a) Choo cha shimo la kaya

3. Je! Unatupaje nyuso za wanadamu? (a) Dampo wazi? (b) Kuzika (c) Kuchoma

4. Unatoa haja kubwa wapi usiku? (a) Shamba la wazi (b) Nyumba ndogo (c) Misitu

5. Je, unasafisha choo / choo chako? (a) Ndio (b) Hapana

6. Unaosha mikono na sabuni baada ya kwenda choo? (a) Ndio (b) Hapana

7. Je unaosha mikono na sabuni kabla ya kula? (a) Ndio (b) Hapana

8. Je! Unaosha matunda na mboga kabla ya kula? (Isoji suji irmatunda omboga etuinyanya)

(a) Ndio (b) Hapana

9. Unakula nyama mbichi? (a) Ndio (b) Hapana

10. Chanzo kikuu cha maji ya kunywa:

(a) Kisima kisicho na kinga (b) kisima (c) maji ya mvua (d) maji kutoka kwa tovuti za asili

11. Je! Unakata kucha? (a) Ndio (b) Hapana

12. Je! Unavaa viatu kila wakati? (a) Ndio (b) Hapana

13. Ni mara ngapi unatoa minyoo? (a) Kamwe (b) Wakati mwingine (c) Daima

14. Ulidumu lini minyoo? (a) miezi 3 iliyopita (b) miezi 6 (c) Kamwe

15. Je! Unaweza kupata kituo cha afya? (a) Ndio (b) Hapana

16. Je! Hospitali, Kituo cha afya, zahanati iko umbali gani? (umbali katika km au saa)

APPENDIX III: ADULT INFORMED CONSENT FORM: ENGLISH-MAA

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ADULT INFORMED CONSENT FORM

TITLE

PREVALENCE OF INTESTINAL PARASITIC INFECTIONS AND ASSOCIATED RISK FACTORS AMONG THE COMMUNITY LIVING IN OLOISUKUT CONSERVANCY, TRANS MARA NAROK COUNTY, KENYA. Eneba ilkuru lootunganak obatishu nayau toltunganak loloisukut Conservancy, Transmara Narok County.

PRINCIPAL INVESTIGATOR AND INSTITUTIONAL AFFILIATION (OLOPENY ENAKISOMA)

Zipporah Njeri Gitau, M.Sc. student, University of Nairobi, Department of Biology.

INTRODUCTION

The consent form is intended to provide details about my study. Finding out the profile of intestinal parasite infections is the goal of the investigation. You are free to accept or reject participating in this study. You are welcome to inquire about any aspect of the study, such as potential advantages or dangers of participating. The principal researcher will explain or read it aloud if the language used in this form is difficult for you to understand or read and comprehend on your own. This form will be translated into your preferred language if you have any trouble comprehending the English used.

Ore ena palai naa peekiwutaki iyiunot enakisoma.Ore ena kisoma naa enoolkuru tooltungana.Ilakuno piyany ashu inyorraa piikinkilikwanishoreki tenakisoma. Ilakuno sii pee inkilikwanu swali yoyote naipirta enakisoma. Ore peemiyelewa enkutuk naitumiyaki tenakisoma naa keitumiyai enkutuk niyelewa iyie openy.

Can I proceed? YES/NO

The Kenyatta National Hospital-University of Nairobi Ethics and Research Committee protocol no. P79/02/2021 has approved this study.

PURPOSE OF THE STUDY (Enkipirta Enkisoma)

The goal of this study is to ascertain the prevalence of intestinal parasite infections (IPIs) and risk variables among among the community living in Oloisukut Conservancy, Trans Mara Narok County, Kenya. The results from this study will help develop measures to prevent intestinal diseases in the conservancy. Ore ekipirta enakisoma naa peinguraa ilkuru looltungana obatishu nayau lelo kuru tooltunganak loiloisukut Conservancy. Ore majibu naatumi tenakisoma naa keisaidia peiboori lelo kuru tooltunganak loloisukut.

THE FOLLOWING WILL TAKE PLACE IF YOU AGREE TO PARTICIPATE.

TENINYORRAA ENAKISOMA NEKINKILIKWANISHOREKI TEKUNA

I will interview you for about five to ten minutes then I will request for your stool, for examination in the laboratory for intestinal worms. I will ask questions on your age, education, and sanitary behaviors. We need to have your consent before we proceed.

I'll need your contact information so I can offer you feedback but it is ok if you don't want to give me your contacts. You can also have my contacts to ask any questions relating to this study. You can have a copy of this form if you want. Aikilikwanishore ildaikini tomon, ore peekindip naipim choo inono. Aikilikwan maswali anaa ilarin linono, enkisoma wee siai enkibooroto olchafu teeyie. Kiiyieu kibali ino peekipuo dukuya.Kiiyieu inambai inonok peekincho iyie majibu, niya nkunaang pinkilikwanu maswali yoyote naipirta emakisoma. Indim aawa empalai nabo naipirta enakisoma.

BENEFITS (DUPOTO ENAKISOMA)

The potential benefit to you in participating in this study is that you will receive educational materials on disease transmission factors and measures to prevent them as well as hygiene practices. There will be no monetary gain but the cost of the laboratory investigations on the stool samples for intestinal parasitic infections will be borne by the principal investigator. I will also give you stool results feedback and advise you how to avoid infection. Being part of this study will not cost you anything, only your time. Ore dupoto enakisoma naa itum impala we ngeno naiboorieki enkitasuroto oo moyiaritin we nkibooroto olchafu tooltunganak. Metii iropiyian naatumi aashu nilak tenakisoma, ore iropiyiani naipimieki choo tesipitali ashu lab naa oloosita enakisoma lolak. Aaisho sii embaare epesho naaikok eningo tenimbooyo moyiaritin. Ore teninyorraa enakisoma mekintalaki toki erishata ake ino iyieuni.

RISKS (ewurisho)

Stool collection is a non-invasive procedure therefore we do not anticipate any risks.

VOLUNTARY PARTICIPATION (AAKU TENEBO ENAKISOMA)

This is scientific research and you need to know the following as a participant:

i) You have the option to volunteer for this study or decline it; ii) You can get out of the study any time you wish; iii) If you don't participate in this study, you will still g*et al*l the benefits from this study. Ore enasiai naa enenkisoma naa keyieu niyielou kuna:

i)Ilakuno piinyorra enakisoma ashu iyany, ii) iindim aipanga tenakisoma esaa yoyote niyieu niimpang, iii) Ore peemiyieu enakisoma neton ake itum dupoto naingwaa enakisoma)

TYPE OF SPECIMEN AND AMOUNT (INTOKITIN NAAYIUNI)

The specimen to be used is stool and about 5-10 grams of stool will be collected. (Ore ntokitin naayiuni naa choo)

RESEARCHERS INFORMATION

These are the contacts of the researcher to ask for any information related to this study in future. Feel free to flash me anytime and I will call you back, and in case I pick your call feel free to demand your call charges from me. Ore kuna ambai naa nolopeny enakisoma, ilakuno piiflash enasimu nekiwoshoki ninye esaa yoyote niyieu

Principal Investigator: Zipporah Njeri Gitau, MSc. Student, department of Biology, University of Nairobi.

Telephone number: 0715324059; Email: gitaunjeri@students.uonbi.ac.ke

KNH/UON/ERC INFORMATION

As a research participant you have rights, Please don't hesitate to get in touch with the Kenyatta National Hospital-University of Nairobi Ethics and Research Committee Secretary/Chairperson at (772) 6300, ext. 44102, or via email at (uonknh erc@uonbi.ac.ke).

STORAGE OF THE SPECIMEN FOR FURTHER ANALYSIS

Specimen will be stored for further analysis at the KEMRI, CMR laboratories. Some specimens may need to be sequenced and therefore shipped out of the country.

STUDY SUBJECT STATEMENT OF CONSENT

I consent to taking part in the study (Anyorraa enakisoma) YES NO

I consent that my stool can be stored for further analysis or later study (Anyorra peeshumi choo ai peejurri tesipitali ashu telab) YES NO

I consent that my stool can be sent abroad for more research. YES NO

I am aware that participating in the study will not result in any financial gain. I am aware that any information I provide will be kept private and that taking part in this study will not have any negative effects on my care. I have the freedom to leave the study whenever I want. I am free to get in touch with the Ethics Review Committee or the Principal Investigator using the above contact information if I have any questions. Anyorra ajo metii ropiyiani naatumi tenanyorraa enakisoma. Atonyorayie ajo erripi neisudoori majibu naishorwa tenakisoma. Alakuno pee aingwaa enakisoma esaa yoyote nayieu. Ore paata maswali naipirta enkisoma nalakuno paawoshoki olopeny enakisoma toonambai naishorwaki tenapalai.

Name/Initials of Study Subject……...…….....

Signature of the subject.....Date.....

Name of Witness……Contact information……

Witness's Signature.....Date.....

I declare that I informed the subject of the study's goals, methodology, possible advantages, and dangers, and that the subject gave his or her free and informed permission.

Principal investigator Signature ……. Date……

APPENDIX IV: PARENTAL INFORMED CONSENT FORM FOR CHILDREN: ENGLISH-MAA

KNH-UoN ERC

Email: uonknh_erc@uonbi.ac.ke

Website: http://www.erc.uonbi.ac.ke

Facebook: ttps://www.facebook.com/uonknh.erc

Twitter: @UONKNH_ERC ttps://twitter.com/UONKNH_ERC

KENYATTA NATIONAL HOSPITAL (KNH)

P O BOX 20723 Code 00202

Tel: 726300-9

Fax: 725272

Telegrams: MEDSUP, Nairobi

UNIVERSITY OF NAIROBI (UoN)

COLLEGE OF HEALTH SCIENCES

P O BOX 19676 Code 00202

Telegrams: varsity (254-020)

2726300 Ext 44355

PARENTAL CONSENT FORM FOR CHILDREN IN THIS STUDY

TITLE

PREVALENCE OF INTESTINAL PARASITIC INFECTIONS AND ASSOCIATED RISK FACTORS AMONG THE COMMUNITY LIVING IN OLOISUKUT CONSERVANCY, TRANS MARA NAROK COUNTY, KENYA. Eneba ilkuru lootunganak obatishu nayau toltunganak loloisukut Conservancy, Transmara Narok County.

PRINCIPAL INVESTIGATOR AND INSTITUTIONAL AFFILIATION

Zipporah Njeri Gitau, M.Sc. student, University of Nairobi, Department of Biology.

INTRODUCTION

The consent form is intended to provide details about my study. Finding out the profile of intestinal parasite infections is the goal of the investigation. You are free to accept or reject participating in this study. You are welcome to inquire about any aspect of the study, such as potential advantages or dangers of participating. The principal researcher will explain or read it aloud if the language used in this form is difficult for you to understand or read and comprehend on your own. This form will be translated into your preferred language if you have any trouble comprehending the English used.

Ore ena palai naa peekiwutaki iyiunot enakisoma.Ore ena kisoma naa enoolkuru tooltungana.Ilakuno piyany ashu inyorraa piikinkilikwanishoreki tenakisoma. Ilakuno sii pee inkilikwanu swali yoyote naipirta enakisoma. Ore peemiyelewa enkutuk naitumiyaki tenakisoma naa keitumiyai enkutuk niyelewa iyie openy.

Can I proceed? YES/NO

The Kenyatta National Hospital-University of Nairobi Ethics and Research Committee protocol no. P79/02/2021 has approved this study.

PURPOSE OF THE STUDY (Enkipirta Enkisoma)

The goal of this study is to ascertain the prevalence of intestinal parasite infections (IPIs) and risk variables among among the community living in Oloisukut Conservancy, Trans Mara Narok County, Kenya. The results from this study will help develop measures to prevent intestinal diseases in the conservancy. Ore ekipirta enakisoma naa peinguraa ilkuru looltungana obatishu nayau lelo kuru tooltunganak loiloisukut Conservancy. Ore majibu naatumi tenakisoma naa keisaidia peiboori lelo kuru tooltunganak loloisukut.

IF YOU AGREE YOUR CHILD TO PARTICIPATES, THE FOLLOWING WILL HAPPEN

I will interview you and your child for about five to ten minutes then I will request your child's stool for examination in the laboratory for intestinal worms. I will ask questions about your child age, education, and sanitary behaviors. You will also receive deworming drugs. We need to have your consent before we proceed.
I'll need your contact information so I can offer you feedback but it is ok if you don't want to give me your contacts. You can also have my contacts to ask any questions relating to this study. You can have a copy of this form if you want. TENINYORRAA ENAKISOMA NEKINKILIKWANISHOREKI TEKUNA
Aikilikwanishore ildaikini tomon, ore peekindip naipim choo inono. Aikilikwan maswali anaa ilarin linono, enkisoma wee siai enkibooroto olchafu teeyie. Kiiyieu kibali ino peekipuo dukuya. Kiiyieu inambai inonok peekincho iyie majibu, niya nkunaang pinkilikwanu maswali yoyote naipirta emakisoma. Indim aawa empalai nabo naipirta enakisoma.

BENEFITS (DUPOTO ENAKISOMA)

The potential benefit to you in participating in this study is that you will receive educational materials on disease transmission factors and measures to prevent them as well as hygiene practices. There will be no monetary gain but the cost of the laboratory investigations on the stool samples for intestinal parasitic infections will be borne by the principal investigator. I will also give you stool results feedback and advise you how to avoid infection. Being part of this study will not cost you anything, only your time. Ore dupoto enakisoma naa itum impala we ngeno naiboorieki enkitasuroto oo moyiaritin we nkibooroto olchafu tooltunganak. Metii iropiyian naatumi aashu nilak tenakisoma, ore iropiyiani naipimieki choo tesipitali ashu lab naa oloosita enakisoma lolak. Aaisho sii embaare epesho naaikok eningo tenimbooyo moyiaritin. Ore teninyorraa enakisoma mekintalaki toki erishata ake ino iyieuni.

RISKS(Ewurisho)

Answering personal questions can be uncomfortable, we will therefore talk to you in private, and promise to do everything possible to protect the information you give us. We will not use your name anywhere in the form, we will use a code instead.
Stool collection is a non-invasive procedure therefore we do not anticipate any risks.

VOLUNTARY PARTICIPATION (AAKU TENEBO ENAKISOMA)

This is scientific research and you need to know the following as a participant:
i) You have the option to volunteer for this study or decline it; ii) You can get out of the study any time you wish; iii) If you don't participate in this study, you will still g*et al*l the benefits from this study. Ore enasiai naa enenkisoma naa keyieu niyielou kuna:
i)Ilakuno piinyorra enakisoma ashu iyany, ii) iindim aipanga tenakisoma esaa yoyote niyieu niimpang, iii) Ore peemiyieu enakisoma neton ake itum dupoto naingwaa enakisoma)

TYPE OF SPECIMEN AND AMOUNT

The specimen to be used is stool and about 5-10 grams of stool will be collected.

RESEARCHERS INFORMATION (Enkarna, onambai olopeny enkisoma)

These are the contacts of the researcher to ask for any information related to this study in future. Feel free to flash me anytime and I will call you back, and in case I pick your call feel free to demand your call charges from me.
Ore kuna ambai naa nolopeny enakisoma, ilakuno piiflash enasimu nekiwoshoki ninye esaa yoyote niyieu.
Principal Investigator: Zipporah Njeri Gitau, MSc student, department of Biology, University of Nairobi.
Telephone number: 0715324059; Email: gitaunjeri@students.uonbi.ac.ke

KNH/UON/ERC INFORMATION

As a research participant you have rights, Please don't hesitate to get in touch with the Kenyatta National Hospital-University of Nairobi Ethics and Research Committee Secretary/Chairperson at (772) 6300, ext. 44102, or via email at (uonknh erc@uonbi.ac.ke).

STORAGE OF SPECIMEN FOR FURTHER ANALYSIS

Specimen will be stored until the study is completed at the KEMRI, Center for Microbiology Research CMR laboratories.

FEEDBACK OF THE STUDY

You will receive the stool analysis results after the end of this study. However, for cases that are positive and need immediate management, the results will be communicated through the county health director as soon as possible. Any recommendations made at the end of this study will also be communicated.

PARENTAL CONSENT STATEMENT

I Understand that this child is below the age of 18 year and legally consent has to be granted by a parent/guardian. I am convinced that both my identity and that of my child will be kept as confidential as possible. Ayiolo ajo eitu eitabaya enakerai ilarin tomon oisiet naa jukumu entoiwuoi peeyany ashu enyorraa peeeikilikwanishoreki enkerai enye.

Signing of this form does in no way whatsoever take away the legal rights of my child as a research subject in this study. Ore tenatukuny enapalai nemeishoyo haki enkerayiai anaa obo loikilikwanishoreki tenakisoma.

I consent to having my child take part in the study. (Anyorraa peeikilikwanishoreki ekerai ai tenkisoma)

YES……... NO ……

I consent that my child's stool can be stored for further analysis or later study (Anyorraa peeshumi choo enkerai neipimi tesipitali ashu lab) YES ……. NO …….

I am aware that participating in the study will not result in any financial gain. I am aware that any information I disclose about my child will be kept private and that taking part in this study will not have any impact on how my child is treated. My child has the freedom to leave the study whenever they choose. I am free to get in touch with the Ethics Review Committee or the Principal Investigator using the above contact information if I have any questions.

Anyorraa ajo metii ropiyiani naaishoori tenakisoma. Anyorraa ajo ore pookitoki naipirta enkerai ai naa kerripi neisudoori tenakisoma. Elakuno enkerai ai peeingwaa enakisoma esaa yoyote nayieu. Ore paata maswali yoyote naa kalakuno paawoshoki olopeny enakisoma toonambai natii atua enapalai.

Name/Initials of Study Subject……...…….....

Subject Signature .....Date.....

Witness Name……Contact information……

I declare that I informed the subject of the study's goals, methodology, possible advantages, and dangers, and that the subject gave his or her free and informed permission. Asip ajo aishorwa olkilikwai oipirta enakisoma odupoto nayau obatishu, netonyorrayie oloikilikwanishoreki aaku tenebo enakisoma.

Principal investigator Signature ……. Date…….

APPENDIX V: CHILDREN ASSENT FORM

KNH-UoN ERC

KENYATTA NATIONAL HOSPITAL (KNH)

UNIVERSITY OF NAIROBI (UoN)

Email: uonknh_erc@uonbi.ac.ke

P O BOX 20723 Code 00202

COLLEGE OF HEALTH SCIENCES

Website: http://www.erc.uonbi.ac.ke

P O BOX 19676 Code 00202

Tel: 726300-9

Telegrams: varsity (254-020)

Facebook: ttps://www.facebook.com/uonknh.erc

2726300 Ext 44355

Twitter: @UONKNH_ERC ttps://twitter.com/UONKNH_ERC

Fax: 725272

MINOR ASSENT FORM

Project Title: PREVALENCE OF INTESTINAL PARASITIC INFECTIONS AND ASSOCIATED RISK FACTORS AMONG THE COMMUNITY LIVING IN OLOISUKUT CONSERVANCY, TRANS MARA NAROK COUNTY, KENYA

Investigator(s): Zipporah Njeri Gitau, M.Sc. student, University of Nairobi, Department of Biology.

We are doing a research study about determining the level of worms and what causes the spread of worms among the families living in Oloisukut Conservancy, Trans mara Narok County.

The Kenyatta National Hospital-University of Nairobi Ethics and Research Committee has given permission to conduct this study (KNH-UoN ERC Protocol No. P79/02/2021).

The purpose of this research study is to better understand humans. You will be taking part in this research project along with at least 282 kids.

If you choose to participate in this study, you will be required to provide 5-10grams of stool for examination in the laboratory for worms. You will also be asked questions about your age, education, and hygiene behaviors. The interview will take five to 10 minutes. You will also be given with deworming drugs.

You should be aware of a few facts concerning this study. Because answering personal questions can be awkward, we'll speak with you in private. and promise to do everything possible to protect the information you give us. We will not use your name anywhere in the form, we will use a code instead. Stool collection is a non-invasive procedure therefore we do not anticipate any risks.

Not every participant in this study will gain anything from it. A benefit is when something favorable occurs to you. You will receive educational materials on what causes worms, signs and symptoms of worm disease and how to prevent worms. Testing of your stool will be free. You will receive stool results and advice on how to avoid worms. Being part of this study will not cost you anything, only your time.

We will inform you of the alternative therapy options available to you if you decide against participating in this research project.

We will compile our findings into a report after this investigation is complete. Your name and participation in the study will not be mentioned in this report.

If you don't want to participate in this study, you are not required to. After we start, it's fine if you wish to stop. Your parents are also aware of the study.

Please sign your name if you desire to participate in the study.

I,_____, would like to participate in this investigation.

_____**(Signature/Thumb stamp) (Date)**

APPENDIX VI: PREPARATION OF REAGENTS AND SOLUTIONS

i. Iodine (Dobell's) for Fecal Preparations

To make about 100ml: requirements- Potassium iodide 4g, Iodine 2g, Distilled water 100ml.

Method

About 50 ml of distilled water was used to thoroughly dissolve 4g of potassium iodide. Iodine (2g) was added and thoroughly mixed. The remaining distilled water was added and solution mixed thoroughly. It was transferred to a brown bottle labeled and marked as **harmful**. It was stored at room temperature in the dark. This reagent has stability for few months. Small amount of the reagent was aliquoted into a smaller brown bottle and capped into which a dropper was inserted for immediate use (Cheesbrough, 2005).

ii. Physiological saline 8.5g/l

To make 1000ml: requirements sodium chloride 8.5g, distilled water 1litre

Method

About 8.5g of sodium chloride was weighed and transferred into a 1-liter leak proof bottle. I liter distilled water added and mixed to completely dissolve the salt. The bottle was labelled and stored at room temperature. The solution is stable for few months (Cheesbrough, 2005).

iii. Carbon fuchsin

To make 1115ml: requirements Basic Fuchsin 10g, Absolute Ethanol or methanol 100ml, Phenol 50g, Distilled water 1 liter

Method

About 10 g of basic fuchsin was weighed and transferred to a 1.5-liter bottle. About 100ml ethanol (ethyl alcohol) or methanol was added and mixed until basic fuchsin dissolved completely. With care, 50g of phenol was weighed in a beaker. To dissolve the phenol, distilled water was measured out and added to the beaker. After that, this mixture was transferred to the bottle stain and thoroughly mixed. The mixture was well-mixed with the remaining distilled water to form stain. The stain bottle was labelled and kept at room temperature. The stain was indefinitely stable. For immediate use, small amounts of stain solution were filtered in small dropper bottle (Cheesbrough, 2005).

iv. Preparation of cellophane and malachite green

To make 100ml: requirements 3g, distilled water 100ml

Method

1. About 3grams of malachite green was weighed and added to 100ml of distilled water.
2. It was mixed well to form a suspension and stored at room temperature.
3. Before use, cellophane was pre-soaked in malachite green solution over night for at least 24 hours.
4. For immediate use, about 3ml of the stock solution was added in a solution mixture consisting of 100ml glycerol +100ml distilled water and mixed well (Cheesbrough, 2005).

v. Alcohol (Ethanol), 95% v/v

To make 100ml: requirements Ethanol (absolute) 95ml, distilled water 5ml.

Method

About 95ml of absolute ethanol was measured using a 100ml cylinder. 5ml distilled water was added. The solution was transferred into a leak proof bottle and thoroughly mixed. The stain bottle was labelled **flammable** and kept at room temperature. This stain was indefinitely stable (Cheesbrough, 2005).

vi. Acid alcohol, 3% v/v (HCL in 70% alcohol)

To make 1 liter: requirements; Absolute Ethanol/Methanol 680ml, Distilled water 290ml, Concentrated Hydrochloric acid 30ml.

Method

About 680ml Ethanol or Methanol was measured and transferred to a 1-liter container. About 290ml of distilled water was measured and added to the alcohol and thoroughly mixed. Then 30ml of concentrated hydrochloric acid was added to the solution and thoroughly mixed. The bottle was tagged with a label that said "flammable" and was kept at room temperature. This reagent is indefinitely stable. For immediate use, small amount of the solution was transferred into a dispensing bottle that can be capped when not in use (Cheesbrough, 2005).

vii. Formol water, 10%v/v

To make a 500ml formalin solution; requirements; 50ml concentrated formaldehyde solution, 450ml distilled water.

Method

A 50 ml formaldehyde was added to 450 ml distilled water to form a solution, thoroughly mixed and labelled in a capped flask. The reagent was stored at room temperature (Cheesbrough, 2005).

APPENDIX VII : OCCURRENCE OF MULTIPLE INFECTIONS (N=411)

Parasites combination	Total count (%)
Multiple protozoa	**48 (11.7)**
Multiple helminths	**9 (2.2)**
Multiple helminths + protozoa	**88 (21.4)**
Total- two multiple	76 (18.5)
G. lamblia, E. histolytica/E. dispar/E. moshkovskii	5
E. coli , E. histolytica/E. dispar/E. moshkovskii	27
T. trichiura, E. histolytica/E. dispar/E. moshkovskii,	16
I. buestchlii, E. histolytica/E. dispar/E. moshkovskii	4
G. lamblia, I. buestchlii	1
G. lamblia, E. coli	2
G. lamblia T. trichiura	6
E. coli, T. trichiura	6
I. buestchlii, T. trichiura	1
A. lumbricoides, T. trichiura	6
T. trichiura, Hookworm	1
S. stercoralis, Hookworm	1
Total-three multiple	43 (10.5%)
E. coli, E. histolytica /E. dispar/E. moshkovskii, T. trichiura	23
G. lamblia, E. histolytica/E .dispar/E. moshkovskii, I. buestchlii	1
I. buestchlii, E. histolytica/E. dispar/E. moshkovskii, Taenia spp.	1
E. coli, I. buestchlii, E. histolytica/E. dispar/E. moshkovskii	4
T. trichiura, E. histolytica/E. dispar/E. moshkovskii, G. lamblia	6
A. lumbricoides, E. histolytica/E. dispar/E. moshkovskii, T. trichiura	1
G. lamblia, T. trichiura, A. Lumbricoides	2
I. buestchlii, T. trichiura, E. histolytica/E. dispar/E. moshkovskii	1
E. coli, I. buestchlii, T. Trichiura	1
E. coli, G. lamblia, E. histolytica/E. dispar/E. moshkovskii	2
T. trichiura, A. lumbricoides, Hookworm	1
Total-four multiple	22 (5.4%)
E. histolytica/E. dispar/E. moshkovskii, E. coli, I. buestchlii, C. mesnili	1
E. histolytica/E. dispar/E. moshkovskii, E. coli, I. buestchlii, T. trichiura	7
E. histolytica/E. dispar/E. moshkovskii, E. coli, A. lumbricoides, T. trichiura	2
E. histolytica/E. dispar/E. moshkovskii, E. coli, I. buestchlii, H. nana,	1
E. histolytica/E. dispar/E. moshkovskii, E. coli, H. nana, T. Trichiura	1
E. histolytica/E. dispar/E. moshkovskii, I. buestchlii, T. trichiura, A. lumbricoides	1
E. histolytica/E. dispar/E. moshkovskii, G. lamblia, T. trichiura, A. lumbricoides	1
E. histolytica/E. dispar/E. moshkovskii, T. trichiura, A. lumbricoides, Hookworm	1
E. histolytica/E. dispar/E. moshkovskii, E. coli, I. buestchlii, G. lamblia,	1
I. buestchlii, T. trichiura, H. nana, Taenia spp.	1
E. coli, G. lamblia, I. buestchlii, T. Trichiura	1

E. histolytica/E. dispar/E. moshkovskii, E. coli, T. trichiura, Hookworm	2
E. histolytica/E. dispar/E. moshkovskii, G. lamblia, E. coli, T. trichiura	1
E. histolytica/E. dispar/E. moshkovskii, G. lamblia, E. coli, Hookworm	1
Total-five multiple	4 (1%)
E. histolytica/E. dispar/E. moshkovskii, G. lamblia, E. coli, I. buestchlii, T. trichiura	1
E. histolytica/E. dispar/E. moshkovskii, E. coli, I. buestchlii, C. mesnili, A. lumbricoides	1
E. coli, G. lamblia, T. trichiura, A. lumbricoides, Hookworm	1
E. coli, H. nana, I. buestchlii, T. trichiura, A. lumbricoides	1

APPENDIX VIII: UNIVERSITY OF NAIROBI APPROVAL LETTER

UNIVERSITY OF NAIROBI
GRADUATE SCHOOL

Telephone: 020491 – 0000/3129
E-mail: gs@uonbi.ac.ke

P. O. Box 30197-00100
NAIROBI, KENYA

Our Ref: I56/34662/2019

15 February 2021

Ms. Gitau Zipporah Njeri
C/ o Director
School of Biological Sciences

Dear Ms. Gitau,

SUBJECT: **RESEARCH PROPOSAL AND SUPERVISORS**

This is to inform you that the Director, Graduate School has approved your research proposal titled: **"Prevalence of Intestanal Parasitic Infections and Associated Risk Factors among the Community of Oloisukul Consevancy, Narok County, Kenya.**

She has also approved **Dr. David Odongo** and **Dr. Ezekiel Mulinge** and as the supervisors of your MSc. thesis.

You should therefore begin consulting them and ensure that you submit your thesis for examination in **July 2021.** The Guidelines on Postgraduate Supervision can be accessed on our website (www.gs.uonbi.ac.ke) while the Research Notebook is available at the University Bookstore.

Yours sincerely,

PHILIP M. MUKOLA (MR)
FOR: DIRECTOR, GRADUATE SCHOOL

C.c. Director, School of Biological Sciences
Dr. David Odongo (Supervisor) School of Biological Sciences
Dr. Ezekiel Mulinge (Supervisor) Centre of Microbiology Research (CMR)

PMM/ rkm

APPENDIX IX: KNH-UON ERC APPROVAL LETTER

UNIVERSITY OF NAIROBI
COLLEGE OF HEALTH SCIENCES
P O BOX 19676 Code 00202
Telegrams: varsity
Tel:(254-020) 2726300 Ext 44355

KNH-UON ERC
Email: uonknh_erc@uonbi.ac.ke
Website: http://www.erc.uonbi.ac.ke
Facebook: https://www.facebook.com/uonknh.erc
Twitter: @UONKNH_ERC https://twitter.com/UONKNH_ERC

KENYATTA NATIONAL HOSPITAL
P O BOX 20723 Code 00202
Tel: 726300-9
Fax: 725272
Telegrams: MEDSUP, Nairobi

Ref: KNH-ERC/A/263

13th August , 2021

Zipporah Njeri Gitau
Reg. No.I56/34662/2019
School of Biological Sciences
College of Biological and Physical Sciences
University of Nairobi

13 AUG 2021

Dear Zipporah

RESEARCH PROPOSAL: PREVALENCE OF INTESTINAL PARASITIC INFECTIONS AND ASSOCIATED RISK FACTORS AMONG THE COMMUNITY IN OLOISUKUT CONSERVANCY, NAROK COUNTY, KENYA (P79/02/2021)

This is to inform you that the KNH- UoN Ethics & Research Committee (KNH-UoN ERC) has reviewed and approved your above research proposal. The approval period is 13th August 2021 – 12th August 2022.

This approval is subject to compliance with the following requirements:

i. Only approved documents (informed consents, study instruments, advertising materials etc) will be used.
ii. All changes (amendments, deviations, violations etc.) are submitted for review and approval by KNH-UoN ERC before implementation.
iii. Death and life threatening problems and serious adverse events (SAEs) or unexpected adverse events whether related or unrelated to the study must be reported to the KNH-UoN ERC within 72 hours of notification.
iv. Any changes, anticipated or otherwise that may increase the risks or affect safety or welfare of study participants and others or affect the integrity of the research must be reported to KNH- UoN ERC within 72 hours.
v. Clearance for export of biological specimens must be obtained from KNH- UoN ERC for each batch of shipment.
vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. (Attach a comprehensive progress report to support the renewal).
vii. Submission of an executive summary report within 90 days upon completion of the study.

APPENDIX X: NACOSTI RESEARCH PERMIT

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: 986515

Date of Issue: 10/September/2021

RESEARCH LICENSE

This is to Certify that Miss.. ZIPPORAH NJERI GITAU of University of Nairobi, has been licensed to conduct research in Narok on the topic: PREVALENCE OF INTESTINAL PARASITIC INFECTIONS AND ASSOCIATED RISK FACTORS AMONG THE COMMUNITY IN OLOISUKUT CONSERVANCY, NAROK COUNTY, KENYA. for the period ending : 10/September/2022.

License No: NACOSTI/P/21/12517

986515

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

APPENDIX XI: APPROVAL LETTER FROM COUNTY HEALTH DIRECTOR, NAROK COUNTY

NAROK COUNTY GOVERNMENT
DEPARTMENT OF HEALTH AND SANITATION

Telegrams: "**HEALTH**", Narok
Telephone: Narok 22300 and 22308
Fax: (050) 22394
Email: countyhealthdirectornarok@gmail.com

COUNTY DIRECTOR OF HEALTH
NAROK COUNTY
P.O. BOX 11- 20500
NAROK

When replying please quote our Ref and date

OUR REF: DIR/NRK CNTY/MOH/60/110 **18th August, 2021**

ZIPPORAH NJERI GITAU
REG. NO.156/34662/2019

RE: RESEARCH AUTHORIZATION

Reference is made to the letter Ref. No. KNH-ERC/A/283 of 13th August, 2021 on Research Proposal.

Authority is hereby granted to the above named to carry out research in Narok County for the period ending **12th August 2022** on ***'Prevalence of intestinal parasitic infections and associated risk factors among the community in Oloisukut Conservancy, Narok County'***. The research should be carried out in conformity with the study protocol and ethics.

The Sub County Medical Officer of Health Transmara West/South is hereby copied for information and support.

18 AUG 2021

Dr. Francis K. Kilo
County Director of Health
NAROK COUNTY

C.C. Sub County Medical Officer of Health
Transmara West/South