EPIDEMIOLOGY OF URINARY SCHISTOSOMIASIS AND SOIL-TRANSMITTED HELMINTHIASIS AMONG WOMEN OF REPRODUCTIVE AGE IN KWALE COUNTY, KENYA

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DECLARATION

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

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DEDICATION

I dedicate this work first and foremost to God Almighty, the source of all knowledge, wisdom, and perseverance. Without His grace and blessings, this accomplishment would not have been possible. To my beloved family: Wife Eversheila, daughters, Blessing Mwende and Hope Makena, my parents, Benard Ngui and Cecilia Kalenge, in-laws and my siblings, your unconditional love, encouragement, and support have been my constant source of motivation. Thank you for always believing in me and inspiring me to pursue my dreams. To my best friend, Gladys Kinya, your unwavering friendship, and insightful advice, have made this journey truly enjoyable and memorable. I am forever grateful for you.

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LIST OF ABBREVIATIONS

FGS	Female Genital Schistosomiasis
MDA	Mass Drug Administration
NTDs	Neglected Tropical Diseases
PCR	Polymerase Chain Reaction
PSAC	Pre-school aged children
SAC	School-aged children
SSA	Sub-Saharan Africa
STH	Soil-Transmitted Helminths
STIs	Sexually Transmitted Infections
WASH	Water, Sanitation and Hygiene
WHA	World Health Assembly

OPERATIONAL DEFINITION OF TERMS

Women of reproductive age- Females between 15-49 years old residing in Mwaluphamba location, Kwale County at the time of the study.

Prevalence of urinary schistosomiasis- The proportion of women of reproductive age with *Schistosoma haematobium* eggs detected in their urine samples using the filtration technique, expressed as a percentage of those tested positive for the disease out of the total number of individuals tested.

Prevalence of soil-transmitted helminthiasis- The proportion of women of reproductive age with soil-transmitted helminth eggs (hookworms, *Ascaris lumbricoides*, or *Trichuris trichiura*) detected in their stool samples using the Kato Katz method, expressed as a percentage of those tested positive for the disease out of the total number of individuals tested.

Intensity of urinary schistosomiasis- The number of *S. haematobium* eggs per 10 mL of urine, categorized as light (1-49 eggs/10 mL) or heavy (≥50 eggs/10 mL) infections.

Intensity of soil-transmitted helminthiasis- The number of soil-transmitted helminth eggs per gram of feces, categorized as light, moderate or heavy infections based on WHO thresholds for each species.

Water, Sanitation and Hygiene (WASH) factors- Factors related to water sources, sanitation facilities, and hygiene practices, as assessed through a standardized questionnaire.

ABSTRACT

Schistosomiasis and soil-transmitted helminthiasis (STH) are prevalent infections in Sub-Saharan Africa especially in low-income setting. School aged children have been the main target of preventive chemotherapy in the national school-based deworming program. This study investigated the epidemiology of urinary schistosomiasis and soil-transmitted helminthiasis among women of reproductive age in Mwaluphamba, Kwale County, Kenya. A community-based cross-sectional study design was employed with a systematic random sampling to recruit 422 women of reproductive age (15-49 years) from four villages in Mwaluphamba location. Stool specimens were collected and examined using the Kato Katz method, while filtration technique was used to analyze urine specimens. Participants' sociodemographic details were obtained using a standardized questionnaire. Statistical analyses were carried out using SPSS version 25, with a significance level set at $p \leq 0.05$. The prevalence of urinary schistosomiasis was 4.7% (95% CI 2.8%-6.9%), while the prevalence of soil-transmitted helminthiasis infection was 4.5% (95% CI 2.6%-6.7%). There were no significant differences in the prevalence of urinary schistosomiasis among different age groups (F=4.454, p=0.196), as well as for hookworms (p=0.235) and *Trichuris trichiura* (p=0.099). Urinary schistosomiasis showed a statistically significant association with haematuria, proteinuria, and leukocyturia. In terms of infection intensities, urinary schistosomiasis ranged from 1 to 120 eggs/10 mL of urine, with a median egg count of 18.45 eggs/10 mL. Patients were diagnosed with light infections of 56.16 eggs/gram and 48.48 eggs/gram for *Trichuris trichiura* and hookworms, respectively. The study revealed that women without latrines had a 15.70 times higher risk of urinary schistosomiasis compared to those with access to latrines. Additionally, the use of surface water (aOR=1.032, 95% CI 1.023-1.432, p=0.010) and crossing rivers (aOR=1.13, 95% CI 0.290-1.611, p=0.009) were identified as statistically significant risk factors for urinary schistosomiasis. In univariable regression analysis, defecating around water sources (OR=4.34, CI 1.466-12.883) was significantly associated with the prevalence of soil-transmitted helminthiasis (p=0.008). This study provides valuable insights into the prevalence and intensity of urinary schistosomiasis and geohelminths in Mwaluphamba location, which can inform the strengthening of control and elimination programs for these neglected tropical diseases. Based on these findings, it is recommended that comprehensive and sustained intervention strategies be implemented, focusing on improving water, sanitation, and hygiene (WASH) practices, enhancing health education, and ensuring regular mass drug administration (MDA) programs.

CHAPTER ONE

INTRODUCTION

1.1. Background information

Schistosomiasis and soil-transmitted helminth (STH) diseases are the predominant parasitic infections worldwide (Sacolo-Gwebu *et al*., 2019). Globally, approximately 2 billion people are infected with at least one species of soil-transmitted helminths, including 1 billion with *Ascaris lumbricoides*, 740 million with hookworms and 464 million with *Trichuris trichiura* (Nisha *et al*., 2020). Schistosomiasis, caused by *Schistosoma* parasites, is widespread worldwide, especially in developing nations. Recent estimates indicate that 779 million individuals are at risk of the infection, with Africa representing 85% of the population at risk. Currently, there are over 207 million individuals in 74 nations harbouring these parasites, leading to the development of the disease in 120 million individuals (Hajissa *et al*., 2018).

In Sub-Saharan Africa, schistosomiasis is responsible for over 200,000 annual deaths (Amuga *et al*., 2020). In Kenya, around 6 million individuals are affected by schistosomiasis, majority of which are women and children. Additionally, another 10 million people are affected by STH (Jeza *et al*., 2022). This persists despite the presence of affordable chemotherapy options like praziquantel for schistosomiasis and albendazole for STH infections, which have been implemented in mass drug administration (MDA) programs. In the case of schistosomiasis, remedies targeting the intermediate host have been implemented in endemic areas. These interventions include environmental management to make habitats less suitable for snails, the use of chemical molluscicides to reduce snail populations, and biological control methods such as introducing predators or competitors to the snails (El-Kady *et al*., 2020).

Since 2012, Kenya has launched a National School-Based Deworming program, targeting the provision of treatment for soil-transmitted helminths (STH) and schistosomiasis to school-aged children. This program extends to primary schools located in 28 endemic counties across various regions of Kenya, implemented through a MDA campaign (MOH-Kenya, 2016; Okoyo *et al*., 2021). A robust monitoring and evaluation (M&E) system has been employed to closely observe the impact of the program on parasitological outcomes among the children who received treatment (Mwandawiro *et al*., 2019). Nevertheless, a nationwide program of this scale is susceptible to various factors, some of which may be beyond the program's influence (Nikolay *et al*., 2015). Furthermore, the existence of water, sanitation, and hygiene (WASH) facilities, along with associated practices and behaviors, plays a crucial role in influencing the likelihood of exposure to pathogens in the environment, such as eggs and larvae. Ensuring that these WASH facilities are adequate and properly utilized is essential for reducing the overall risk of infection and enhancing the effectiveness of the deworming program (Strunz *et al*., 2014).This promotes sustained transmission in these endemic areas.

The coastal region of Kenya exhibits high levels of endemicity for urinary schistosomiasis, although significant spatial and temporal variations are observed (Mutuku *et al*., 2011). Schistosomiasis tends to affect impoverished rural communities where fishing and agriculture are primary economic activities. The infection in humans is typically caused by five *Schistosoma* species: *S. mansoni*, *S. haematobium*, *S. japonicum*, *S. mekongi*, and *S. intercalatum*. However, in Sub-Saharan Africa, *S. mansoni* and *S. haematobium* are the most commonly encountered species (Fatimah *et al*., 2015). In Kwale, *S. haematobium* is the prevalent species, which can be attributed to the tropical climate providing optimal temperatures for parasite development and reproduction within the intermediate snail host *Bulinus nasutus*, enabling year-round transmission suited to *S. haematobium* in this region (Stothard *et al*., 2013).

In the male and female urinary systems, untreated *Schistosoma* infection may cause painful urination, haematuria, and inflammatory and granulomatous lesions (Kaiglová *et al*., 2020). Acute schistosomiasis typically resolves within weeks, and egg-laying by the worms starts approximately 5-7 weeks post-initial infection, leading to the chronic phase of schistosomiasis. Chronic infections by *S. haematobium* lead to Female Genital Schistosomiasis (FGS) which results to a range of gynaecological symptoms and signs in women (Holmen, 2016). Grainy and homogeneous yellow sandy patches, and rubbery papules are all clinical features of FGS (Sturt *et al*., 2020). If not treated FGS can result to infertility, miscarriages, ectopic pregnancies, abortions, stigmatization, nodules around the vulva, and the genital lesions (Kukula *et al*., 2018). Numerous epidemiological investigations have indicated that female genital schistosomiasis (FGS) plays a role in the horizontal transmission of HIV/AIDS among women in their reproductive years (Hotez *et al*., 2019). In addition, a regression analysis that examined the occurrence of *S. haematobium* infection and HIV in SSA countries demonstrated that the relative prevalence of HIV increased by 3% for every 100 individuals infected with *S. haematobium* (Ndeffo Mbah *et al*., 2013).

The primary causes of STH include *A. lumbricoides* and *T. trichiura*, which are contracted by ingesting eggs from contaminated soil, as well as hookworms, which infect through larval penetration of the skin (World Health Organization, 2011). Mature worms can live for years and produce many eggs in 4–6 weeks. Depending on the environmental conditions, STH ova and larvae may survive in the soil for a couple of months (Brooker *et al*., 2006). STH infections are capable of causing harm to both bodily growth and development, mental activity, verbal and cognitive abilities (Bajiro *et al*., 2018). The high STH endemicity in coastal Kenya coupled with vulnerabilities of rural women place this study population at substantial risk of intestinal helminth induced morbidities.

Preventive anthelminthic chemotherapy, administered through mass drug administration (MDA), is advised to safeguard against the morbidities associated with these infections (Okoyo *et al*., 2020). In regions where these diseases are common, preventive public health strategies include administering albendazole or mebendazole for STH infections, and praziquantel for *Schistosoma* infections once or twice a year, based on the area's exposure level (Mwandawiro *et al*., 2019). Praziquantel was found to be ineffective in treating about 1–2.4 percent of 1000 patients infected with schistosomiasis in a study of Egyptian villagers (El-Kady *et al*., 2020). They also discovered praziquantel-resistant strains capable of withstanding high drug doses. Molecular epidemiological research on schistosomiasis has paved the way for exploring key areas, such as understanding how parasite genetics impact variations in disease burden and pathology, transmission dynamics in endemic areas, and the potential spread of drug resistance (El-Kady *et al*., 2020). *S. haematobium* genetic variation is understudied in contrast to *S. mansoni* because of high cost in maintenance of laboratories as well as unavailability of specific molecular markers (Golan *et al*., 2008). Additionally, to integrate the control for these helminth infections, measures aimed at improving access to WASH are encouraged (Echazú *et al*., 2015).

Urinary schistosomiasis and geohelminths are health issues in the rural areas of Kwale County, Coastal Kenya (Njenga *et al*., 2014). In June 2012 study, a significant rise in *Schistosoma* species infection among school going children was observed, from 15.4 to 29.9 percent, and this was after a six-month survey after deworming (Njenga *et al*., 2014). Adult infections are far less targeted compared to children (Crompton & Nesheim, 2002). Despite all possible consequences of these infections among women of reproductive age, this group has remained understudied and neglected in many endemic regions of the world, with most control programs focusing on school aged children. This study assessed the epidemiology of urinary schistosomiasis and soil-transmitted helminthiasis among women of reproductive age in Kwale County, Kenya.

1.2. Statement of the problem

Schistosomiasis and STH have remained a public health concern in Kenya for decades, despite attempts to contain the disease (Chadeka *et al*., 2017). Although, individuals in all age groups are predisposed to these infections, school children and women of reproductive age are considered to be at high risk of the infections and resulting morbidities (Nyika Ngaluma *et al*., 2020). However, one of the most significantly affected groups are women of reproductive age, due to the impact of these worms on the reproductive system. This can lead to infertility, abortion, vaginal discharge, genital itching, and dyspareunia (Rite, 2019). Epidemiological data suggests that these infections can significantly impact reproductive health. For instance, studies have shown that urogenital schistosomiasis prevalence can reach up to 30% in women living in endemic area (Nyika Ngaluma *et al*., 2020).

Comparative data highlights the discrepancy in infection rates between demographic groups. In coastal Kenya, where urogenital schistosomiasis is hyper-endemic, the prevalence among women of reproductive age is notably high. A study conducted in the region reported a prevalence of 20.0% in Mwachinga to 58.3% in Lutsangani among women aged 15-45 years (Kihara *et al*., 2015), compared to lower rates observed in school-aged children (12-15%) (Kariuki *et al*., 2022). Despite these findings, there remains a significant knowledge gap regarding the epidemiology of schistosomiasis and STH among women of reproductive age in specific endemic settings such as Mwaluphamba location, Kwale County. This study aimed to address this gap by investigating the epidemiology of these infections and assessing the role of water, sanitation, and hygiene (WASH) practices in their transmission. This research is crucial for developing targeted interventions to mitigate the health impacts on women of reproductive age and improve overall public health outcomes.

1.3 Justification of the study

Sustained transmission of schistosomiasis and STH infections despite the vibrant intervention mechanisms is of public health concern. Infection with STH especially moderate and heavy intensity infections, are likely to worsen blood loss caused by menstruation, pregnancy, and childbirth (World Health Organisation, 2018). The development of *Schistosoma* eggs in the reproductive system, leading to Female Genital Schistosomiasis (FGS), is a major cause of morbidity in women (Picchio *et al.*, 2020). Low birth weight, miscarriage, ectopic pregnancies, and primary and secondary infertility are all reproductive complications caused by this disease (Picchio *et al.*, 2020). Information regarding the prevalence and intensity of urinary schistosomiasis and soil-transmitted helminthiasis (STH) in the specific demographic will assist in formulating treatment plans for these infections. Additionally, it will add to the pool of evidence concerning the seriousness of these diseases, facilitating the inclusion of women of childbearing age in national disease control initiatives.

1.4. Research objectives

1.4.1 General objective

The general objective of the study was to assess the epidemiology of urinary schistosomiasis and soil-transmitted helminthiasis among women of reproductive age in Kwale County, Kenya.

1.4.2. Specific objectives

1. To assess the influence of demographic characteristics on the epidemiology of urinary schistosomiasis and soil-transmitted helminthiasis among women of reproductive age in Mwaluphamba, Kwale County.
2. To determine the prevalence of urinary schistosomiasis and soil-transmitted helminthiasis among women of reproductive age in Mwaluphamba, Kwale County.
3. To determine the intensity of urinary schistosomiasis and soil-transmitted helminthiasis among women of reproductive age in Mwaluphamba, Kwale County.
4. To assess the influence of WASH on transmission dynamics of schistosomiasis and soil-transmitted helminthiasis among women of reproductive age in Mwaluphamba, Kwale County.

1.5. Research questions

1. What is the influence of demographic characteristics on the epidemiology of urinary schistosomiasis and soil-transmitted helminthiasis among women of reproductive age in Mwaluphamba, Kwale County?
2. What is the prevalence of urinary schistosomiasis and soil-transmitted helminthiasis among women of reproductive age in Mwaluphamba, Kwale County?
3. What is the intensity of urinary schistosomiasis and soil-transmitted helminthiasis among women of reproductive age in Mwaluphamba, Kwale County?
4. What is the influence of WASH on transmission dynamics of schistosomiasis and soil-transmitted helminthiasis among women of reproductive age?

CHAPTER TWO

LITERATURE REVIEW

2.1. Global prevalence and burden of schistosomiasis

The burden of urinary schistosomiasis extends beyond the immediate health impacts. It can cause long-term health problems, such as kidney and bladder damage, urogenital tract abnormalities, and an increased likelihood of acquiring bladder cancer. Additionally, the disease can lead to social and economic consequences, including reduced school attendance and work productivity, due to its impact on affected individuals, especially children and young adults (Crompton, 2006). To tackle the worldwide impact of urinary schistosomiasis, initiatives are underway to eradicate the disease through preventive chemotherapy employing praziquantel, a reliable and safe medication for treating schistosomiasis. Mass drug administration (MDA) initiatives are being rolled out in regions with high-risk factors to decrease infection rates and associated morbidity. Furthermore, interventions related to WASH are vital in preventing transmission by ensuring access to clean water, enhancing sanitation infrastructure, and promoting hygienic behaviors (Tchuenté *et al*., 2017).

A recent systematic review and meta-analysis revealed that schistosomiasis continues to be highly prevalent and problematic among pregnant women worldwide. The study found pooled prevalence estimates of 13.44% for *S. haematobium*, 12.18% for *S. mansoni*, and 53.54% for *S. japonicum*, highlighting the ongoing maternal-child health burden in endemic regions (Cando *et al*., 2022). Another review found that schistosomiasis affects 250 million people worldwide, accounting for 1.43 million DALYS annually (Anisuzzaman & Tsuji, 2020). Together, these findings highlight the considerable global impact of schistosomiasis, including among vulnerable pregnant populations who can experience pregnancy complications. There is a need for greater prevention and control efforts targeting women of reproductive age in endemic regions.

2.2. Global prevalence and burden of soil-transmitted helminthiasis

Soil-transmitted helminths (STH) infections are highly prevalent, affecting millions of individuals worldwide, with a pronounced burden in sub-Saharan Africa, Southeast Asia, and Latin America (Ribado Meñe *et al*., 2023). Approximately 1.3 billion individuals are affected by hookworm, with the WHO reporting that 878 million school-going children are at risk. Hookworm is responsible for an approximated 65,000 deaths each year and results in 845,000 Disability-Adjusted Life Years (DALYs). Additionally, it leads to a productivity loss ranging from 6% to 35.3% (Tsuji, 2020).

The burden of STH infections is of great concern among children, as these diseases can cause malnutrition, anemia, stunted growth, and impaired cognitive growth. This impact on children's health and development has extensive repercussions, influencing educational achievement and overall well-being (Fauziah *et al*., 2022). According to a study by Montresor *et al*. (2022) examining the reduction in DALYs lost due to STH and schistosomiasis between 2000 and 2019, it was found that over 4.1 million DALYs were estimated to have been lost due to STH in the year 2000, decreasing to around 2.8 million in 2010, and further declining to around 2 million in 2019 (a 53 percent decrease from 2000). Conversely, schistosomiasis was responsible for over 2.3 million DALYs lost in 2000, decreasing to around 2.2 million in 2010, and an anticipated 1.7 million in 2019, demonstrating a 24 percent reduction since 2000 (Montresor *et al*., 2022).

The prevalence and intensity of STH and schistosomiasis, as well as the levels of malnutrition and access to sanitary facilities, were examined in pre-school aged children (PSAC) and school aged children (SAC) across two provinces. The study found that the prevalence of any STH was 50.3% in PSAC and 41% in SAC. Additionally, moderate to heavy intensity STH prevalence was 20.8% in PSAC and 5.9% in SAC, indicating significantly higher rates among PSAC across various STH indicators. The assessment also included the prevalence of stunting, underweight, wasting, overweight/obesity, and anemia. Among PSAC, the rates were 38.4% for stunting, 24.5% for underweight, 4.8% for wasting, 2.7% for overweight/obesity, and 34.7% for anemia. Among SAC, the rates were 34.3% for stunting, 21.6% for underweight, 8.7% for wasting, 3.0% for overweight/obesity, and 19.2% for anemia. Anemia was found to be more prevalent in PSAC, while wasting was more prevalent in SAC. Associations between STH and anemia were observed, with higher rates of both conditions in barangays that had not achieved Zero Open Defecation (ZOD) status (Sartorius *et al*., 2021).

2.3. Pathology and clinical manifestation of schistosomiasis and geohelminths

STH and schistosomiasis are neglected tropical diseases that lead to acute and chronic illnesses (Molvik *et al*., 2017). In schistosomiasis, the infected intermediate host releases cercarial forms, which enter the skin upon contact with contaminated water. The adult worms then migrate to either the intestinal or bladder tissues, where they deposit their eggs. In cases of *S. haematobium*, adult worms migrate to the blood vessels around the genitourinary tract to lay their eggs (Nation *et al*., 2020). Among women, this leads to female genital schistosomiasis, a highly neglected gynaecologic condition across sub-Saharan Africa. This disease is estimated to be in tens of millions in its prevalence. Grainy and homogeneous yellow sandy patches, and rubbery papules are all clinical features associated with FGS. FGS can lead to increased susceptibility to HIV and Human Papilloma virus (Kukula *et al*., 2018).

The symptoms of this type of schistosomiasis are usually confused with those of sexually transmitted infection, leading to delayed treatment and allowing the parasitic infection to persist. Prolonged infections can result in impaired tissue function. Across Sub-Saharan Africa, there exists an "infertility belt" where infertility rates can reach as high as 30% in certain areas. FGS can lead to infertility in both men and women, although it is more frequently observed in women. In women, infertility may be attributed to ovarian fibrosis or blockages in the fallopian tubes (Howell, 2020).

STH are characterised as common chronic human infections that are dominant in impoverished areas where hygiene and sanitation is a problem (Hotez *et al*., 2006). The severity of these infections is strongly linked to the infection intensity, with the majority of individuals hosting only a few worms. Chronic infections can result to anaemia, hindered development, and cognitive impairment, particularly in individuals with a high worm burden, although consistent treatment with anthelmintic drugs can reverse most of these health issues (Brooker & Bundy, 2013).

If left unaddressed, STH infections can result in debilitating illnesses, predominantly impacting children and women at childbearing age. The disease intensity correlates directly with the quantity of worms hosted by the individual. While individuals with light infections may not display symptoms, those with heavy infections can suffer from various health complications (World Health Organisation, 2012). Severe infections with *Ascaris* worms can lead to vitamin A deficiency, acute intestinal obstruction, and ascariasis affecting the liver, bile ducts, and pancreas (Walker *et al*., 2011). Heavy

Trichuris infections results in finger clubbing and a condition known as "*Trichuris* dysentery syndrome," characterized by symptoms such as rectal bleeding and rectal prolapse (Middleton, 2017). Severe hookworm infection is mainly linked to conditions like anemia, protein deficiency, and negative birth outcomes, that includes infant mortality and low birth weight (Loukas *et al*., 2016).

2.4. Schistosomiasis in women of reproductive age

Schistosomiasis, being a poverty-related parasitic infection, is ranked second common disease in SSA among the neglected diseases (Atuheire *et al*., 2020). NTDs in Sub-Saharan cause about 534,000 annual deaths and a loss of estimated 57 million years of life lived with disability (Essien-Baidoo *et al*., 2023). In endemic areas, women are vulnerable to *Schistosoma* infections, with 5 to 67 percent prevalence rates. Schistosomiasis in women has been reported in SSA since antiquity, with the major pathology involving female genitalia (Salawu & Odaibo, 2014). The causes of female infertility are estimated to contribute to approximately 25% to 37% of infertility cases globally, with the pronounced rates observed in Sub-Saharan Africa (SSA) and Southeast Asia. A study involving 483 women from Zimbabwe, where the husbands' infertility was ruled out, found a notable correlation between the existence of *Schistosoma* eggs in cervical smears and infertility (Christinet *et al*., 2016). Schistosomiasis control strategies mainly prioritize preventing morbidity, while diagnosing FGS in laboratories remains challenging. Women suffering from FGS go to physicians with reports of bleeding, infertility or suspicion of contracting STIs. Thus, schistosomiasis genital tract lesions receive little attention since they necessitate well-trained physicians and specialist facilities, both of which are in short supply in most schistosomiasis-endemic areas (Christinet *et al*., 2016).

A systematic review carried out during the period of 2016 to 2020 examined the prevalence of urinary schistosomiasis in women, finding a combined prevalence rate of 17.5% (95% CI: 14.8–20.5). The majority of studies (73) were conducted in Nigeria, while the prevalence was observed to be highest in Mozambique at 58%. Analyzing sample types and symptoms, higher frequencies of female urogenital schistosomiasis (FUS) were observed in vaginal lavage samples at 25.0% and in cases of haematuria at 19.4%. The study indicated that women residing in endemic regions of Africa face a moderate risk of developing FUS, which can lead to serious health consequences such as renal failure, urinary bladder cancer, and reproductive issues including dyspareunia and infertility caused by granulomas (Shams *et al*., 2022).

Recent cross-sectional study carried out by Ngassa *et al*. (2023), examined the prevalence of urogenital schistosomiasis among women at childbearing age in Kileo village, Mwanga District of Tanzania. The research utilized questionnaires and urine sedimentation tests to assess disease prevalence, knowledge about the disease, and water contact behaviors associated with transmission risk. The study revealed an overall prevalence rate of 2.3% for urogenital schistosomiasis, indicating relatively low community transmission. However, higher prevalence rates were observed among women aged over 18 years (3.2%), those engaged in domestic chores in rivers (13.3%), and individuals who swam (7.1%). Despite most women having moderate knowledge and practices regarding schistosomiasis, there were still gaps in awareness of precise causal pathways and associated risk factors. While highlighting the need for continuing public health education, the low infection prevalence provides reassurance that mass drug administration efforts have mitigated endemic urogenital schistosomiasis among reproductive-aged women (Ngassa *et al*., 2023).

In a cross-sectional study conducted in Kwale County, Kenya, Jeza *et al*. (2022) examined the prevalence and risk factors associated with simultaneous infections of schistosomiasis, STHs, and malaria among women aged 15 to 50 years. The study revealed a total prevalence of 3.8%, 5.6%, and 4.9% for *S. haematobium*, STHs, and malaria, respectively. However, the occurrence of co-infections was relatively low, affecting less than 1% of both pregnant and non-pregnant participants. The study also noted encouragingly high rates of bed net ownership (87.8%) and access to improved water (66.3%) and sanitation (78.1%) facilities. The researchers conclude that strengthened WASH infrastructure and malaria control efforts involving mass bed net distribution may be suppressing transmission and morbidity from these neglected tropical diseases among reproductive-aged women in this setting (Jeza *et al*., 2022). Nonetheless, continued access to preventative chemotherapy and public health education should accompany further improvements towards universal coverage with protective interventions. Schistosomiasis poses specific challenges for women of childbearing age, especially with the development of FGS. The significant public health concern posed by FGS on fertility, along with its connection to other infections, underscores the importance of addressing this issue in affected areas. This requires the implementation of holistic control and prevention measures. These encompass regular treatment, health promotion campaigns, and enhancing presence of clean water and sanitation facilities (Bustinduy *et al*., 2022).

2.5. Schistosomiasis and soil-transmitted helminths in Kenya

In Kenya, *S. haematobium* and *S. mansoni* are the predominant *Schistosoma* species (Gichuki *et al*., 2019). *S. haematobium* is responsible for causing illness in rural areas, with its transmission closely tied to human contact with freshwater sources. Female *Schistosoma* parasites deposit eggs within the human body, which are later expelled in either urine or feces. Approximately half of these eggs become trapped in tissues, leading to infections in either the bladder (*S. haematobium*) or liver (*S. mansoni*). Schistosomiasis is prevalent in 32 counties in Kenya, specifically in the Lake Victoria area, certain areas in Central Kenya, the Lower Eastern region, and the Coastal region (Murkomen *et al*., 2019).

Recent data suggests that approximately 54% of the 290 sub-counties in Kenya are affected by schistosomiasis, with around nine million individuals infected and approximately eighteen million at-risk of acquiring the disease (Kepha *et al*., 2023). Sassa *et al*. (2020) undertook research to assess the occurrence of *S. mansoni* infection among children below two years old in Mbita Sub-County, Western Kenya. Out of 305 children with complete data, 276 (90.5%) tested positive for *S. mansoni* infection using the point-of-care test for urinary circulating cathodic antigen (POC-CCA), while only 11 children (3.6%) tested positive using the Kato-Katz method (Sassa *et al*., 2020). These findings emphasize the vital need for early screening and intervention techniques that address the high prevalence of schistosomiasis in this region, particularly among vulnerable groups.

A study by Okoyo *et al*. (2022) examined STH and *Schistosoma* infections in Kenya, focusing particularly on their prevalence, severity, and associated risk factors following five rounds of MDA. The study found that the prevalence of *S. mansoni* infection was highest in the Western area (6.3%), Eastern region (2.4%), Nyanza (1.9%), and Coastal regions (0.3%). Notably, there were no recorded instances of *S. mansoni* infection in the North Eastern and Rift Valley areas. In addition, the occurrence of *S. haematobium* infection was found to be relatively minimal in the Coast (0.4%) and North Eastern (0.3%) areas, with no instances detected in the Eastern region (Okoyo *et al*., 2022). These results emphasize the significance of adjusting control tactics for schistosomiasis according to local epidemiological trends and the necessity of focused interventions and ongoing surveillance, even following several cycles of MDA.

STH infections are common in Kenya, particularly in places with limited access to clean water, poor sanitation, and lack of knowledge on prevention measures. Following five rounds of MDA, the countrywide STH infections prevalence was 12.7% (Okoyo *et al*., 2022). The prevalence, however, differed greatly by location, with the highest rates found in Nyanza (15.3%), the Western (20.4%), and the Coastal (22.8%) regions. These results demonstrate that despite initiatives like widespread drug administration campaigns, STH infections continue to pose a health problem in some parts of Kenya.

In the rural regions of Western Kenya, STH infections have been widely documented as a prevalent and persistent health concern, with pregnant women being a vulnerable population. A study conducted in Vihiga, revealed an alarming prevalence rate of 12.4% for STH infections within this demographic group (Araka e*t al*., 2022). This distressing statistic underscores the urgency of implementing comprehensive measures to mitigate the detrimental impact of these infections on both maternal well-being and fetal development. The study's finding serves as a reminder of the imperative need for concerted efforts to address the persistent challenge of soil-transmitted helminth infections, particularly in vulnerable populations such as women at childbearing age residing in resource-constrained rural settings.

A cross-sectional study carried out among 731 children aged between 4-16 years from seven primary schools in the Western region uncovered a significant prevalence of STH infections among the sampled students, with 44.05% testing positive. Of the surveyed schools, Shitaho primary school exhibited the greatest prevalence rate, with 62.6% of the 107 participants infected, while Iyenga primary school had the lowest prevalence at 26.7% among the 101 participants. Notably, *A. lumbricoides* was identified as the predominant STH species, affecting 43.5% of the children, whereas hookworm infections were relatively infrequent at 1.8%. The study concluded that STH infection rates in Kakamega County remain persistently elevated, emphasizing the critical need to implement and expand guidelines and other control strategies to interrupt transmission cycles (Okoyo *et al*., 2023).

2.6. *Schistosoma* species life cycle

Schistosomes have an intricate life cycle involving two different hosts: snails and mammals. In the freshwater snail host, the parasites undergo asexual reproduction. The miracidia undergo transformation into sporocysts, which multiply and become cercariae. These cercariae then infect the mammalian host, where they mature and lay eggs. The eggs are expelled from mammalian host through faeces or urine and end up in freshwater environments. There, the eggs hatch and infect snail hosts, continuing the cycle. Different *Schistosoma* species have preferences for specific snail genera or species as their intermediate hosts. For instance, *S. haematobium* infects snails of the *Bulinus* genus, S. *japonicum* infects *Oncomelania* snails, and *S. mansoni* infects *Biomphalaria* snails.

After entering the snail host, the miracidium transforms into a mother sporocyst. The mother sporocyst then produces daughter sporocysts through asexual reproduction. Infected snails have the ability to release a significant amount of cercariae on a daily basis. The estimated numbers are over 180 for *S. haematobium*, between 15 and 160 for *S. japonicum*, and ranging from 250 to 600 for *S. mansoni*. Upon penetrating human skin, cercariae undergo a process in which they lose their forked tails and transform into schistosomula. The schistosomula undergo migration throughout the bodily tissues and then undergo maturation into fully developed adult *Schistosoma* worms. The precise localization of the mature worms inside the human host is contingent upon the individual *Schistosoma* species. *S. haematobium* is often located in the bladder and ureters, and sometimes in rectal venules. *S. japonicum* mostly dwells in the small intestine, but *S. mansoni* may occupy either the large or small intestine and has the ability to migrate between the two (Nelwan, 2019).

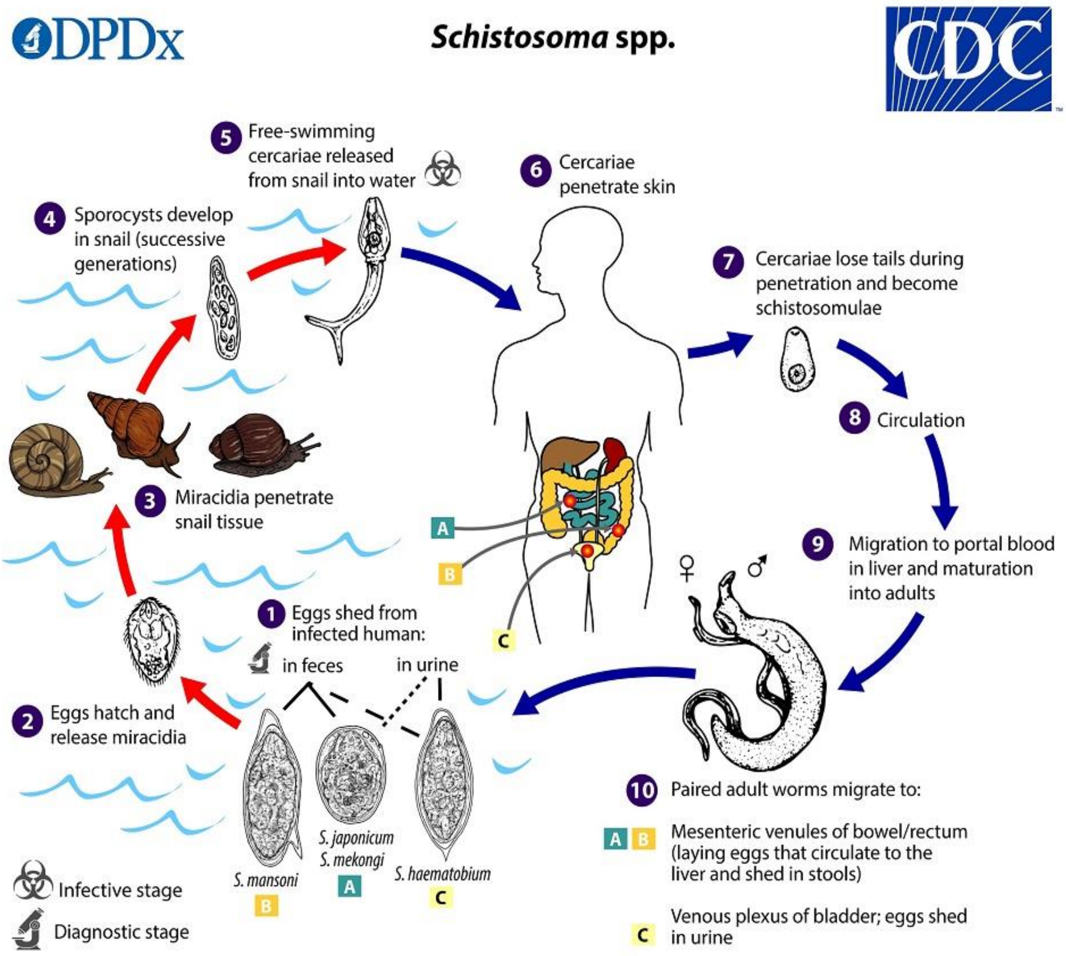


Figure 2.1. Generalized lifecycle of *Schistosoma* species. Source: (CDC, 2019)

2.7. Soil-transmitted helminthes life cycles

Female whipworm adult worms lay between 3,000 to 20,000 eggs daily, passed in the faeces. Once in soil, these eggs progress through various developmental stages, including a 2-cell stage, advanced cleavage stage, and eventual embryonation (Figure 2.2). Environmental factors like high humidity and warm temperatures accelerate this embryo development process. Under ideal conditions, embryonic development takes place over a period of 15 to 30 days. When embryonated eggs are ingested by humans, larvae are released into the upper duodenum. The larvae of the whipworm then undergo moulting and migrate to the colon, where they embed themselves into the epithelial lining. Within approximately 12 weeks, they mature into adult whipworms. The cecum, which is the pouch-like beginning of the large intestine, is typically the preferred site of invasion for these parasites. However, in cases of severe infections, the adult whipworms may spread throughout the entire colon and even reach the rectum in order to obtain nutrients, especially for the more mature parasites (Yousuf *et al*., 2022).

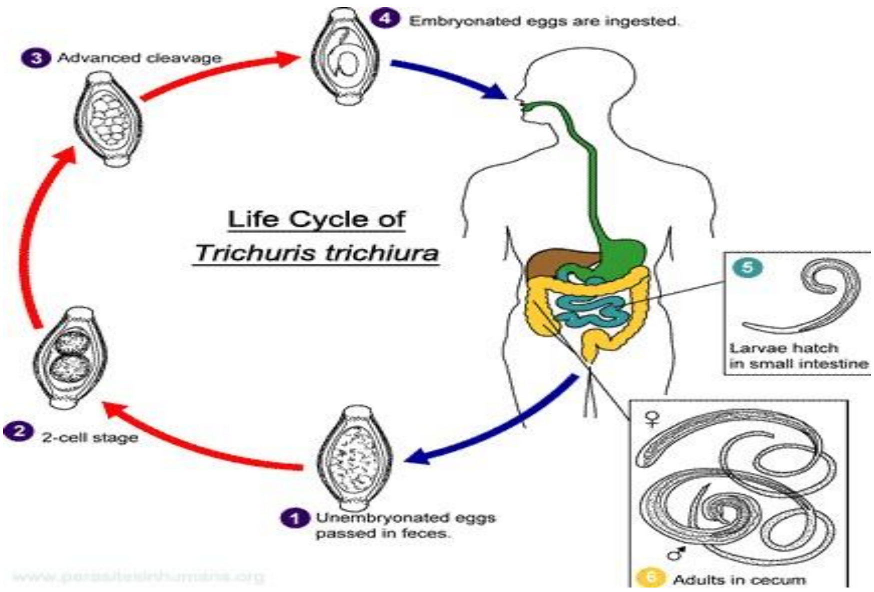


Figure 2.2. Life cycle of *Trichuris trichiura* (CDC, 2017)

A. lumbricoides eggs undergo a developmental phase in the soil before being ingested (Figure 2.3). Once ingested, larvae are released in the stomach, where they penetrate the intestinal wall and enter the liver through the portal circulation. From there, they can get into the heart through the bloodstream and lungs via the pulmonary circulation. Subsequently, the worms travel via the respiratory system and enter the esophagus, ultimately reaching the gut where they undergo maturation into adult worms. After being expelled from the host through faeces, the eggs undergo embryonation in the soil, and the developed eggs are then ingested again (Tameemi *et al*., 2019).

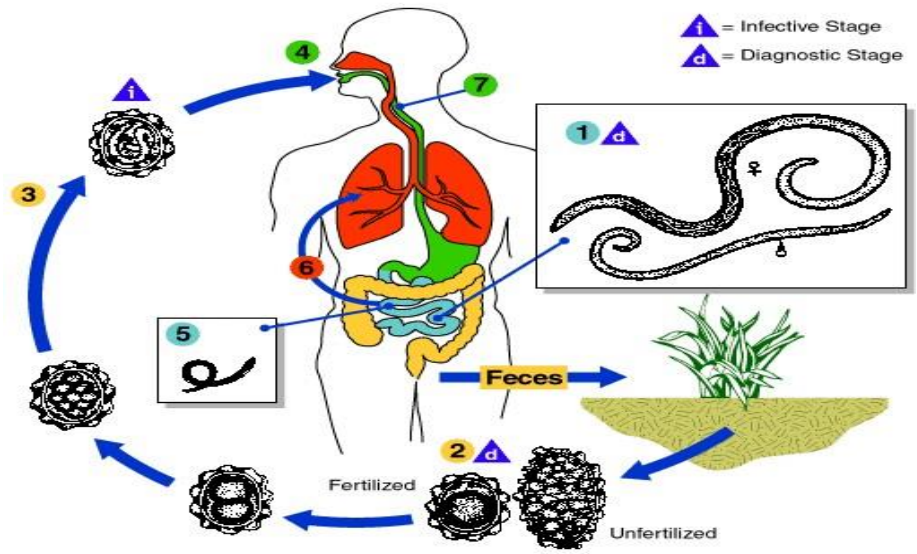


Figure 2.3. Life cycle of *Ascaris lumbricoides* (CDC, 2017)

The mature hookworms inhabit the small intestine, where they securely fasten themselves to the mucous membrane lining. The adult female worms release eggs into the gut, which are then excreted through the faeces. Under suitable environmental conditions like moisture, shade, and warm soil, these excreted eggs hatch into larvae. The newly formed larvae undergo development into an infective filariform stage capable of penetrating human skin. Once inside the human body, the larvae enter the circulation and reach the lungs. They then ascend through the respiratory tract, enter the oesophagus, and eventually they retreat to the small intestine and undergo maturation into adult hookworms. The lifespan of these parasites varies, with *Necator americanus* living approximately 4-5 years, while *Ancylostoma duodenale* has a lifespan of around 6-8 years within the human host. (Ghodeif & Jain, 2019). (Figure 2.4)

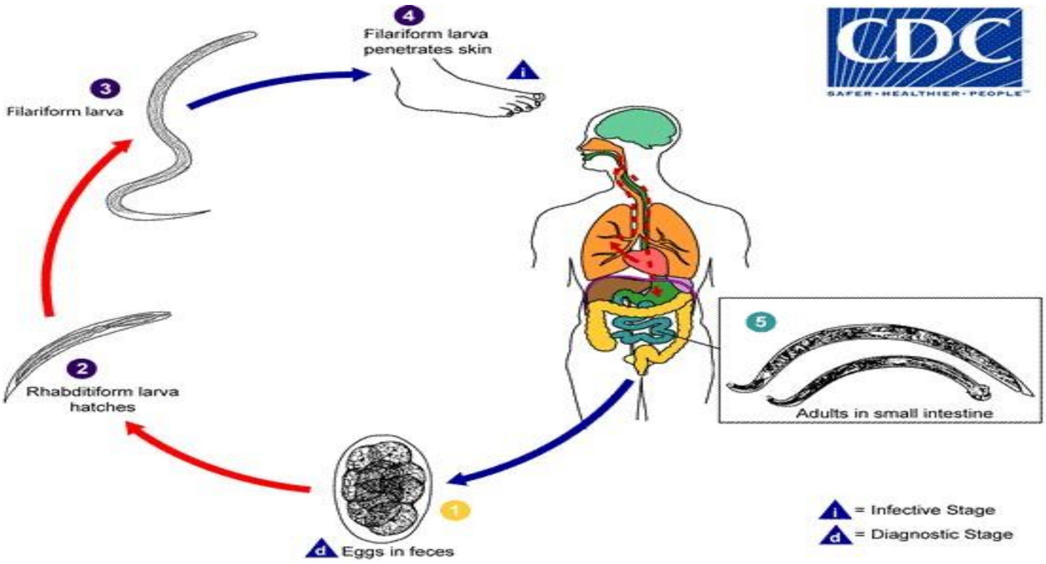


Figure 2.4. Life cycle of the human hookworm (CDC, 2017)

2.8. Impact of WASH on schistosomiasis and soil-transmitted helminthiasis

Water, Sanitation, and Hygiene (WASH) are vital in controlling and preventing both Schistosomiasis and STH. These NTDs are strongly linked to inaccessibility to clean water, poor sanitation practices, and unhygienic behaviors. Implementing WASH interventions can substantially decrease the transmission and impact of these parasitic infections (Mancini, 2023).

Since the year 2000, anthelminthic chemotherapy is cornerstone prevention technique for NTDs including STH, and schistosomiasis, as well as a key component in eliminating Trachoma infections (Campbell *et al.*, 2018). Being delivered through mass drug distribution programs these measures typically target care to school-aged children (Campbell *et al.*, 2018). The limitation with preventive chemotherapy is that it cannot prevent reinfection and therefore alone cannot achieve a stable elimination of STH and schistosomiasis (Brooker *et al*., 2006).

Furthermore, re-establishment in schistosomiasis transmission can be seen from a small number of infected individuals who may infect intermediate snail vector upon contaminating the aquatic environment, which raise the potential of infection by releasing millions of cercariae exponentially (Brooker *et al*., 2006). Though the focus has been on preventive chemotherapy, progress on WASH has been aided as a cornerstone of NTD control (WHO, 2017). It is essential to have access to clean water supply, properly built waste disposal structures to ensure safe disposal of human excreta, and proper hygiene (Campbell *et al*., 2014). Following the introduction of improved WASH services, there was a 29 percent and a 77percent reduction in *A. lumbricoides* and schistosomiasis prevalence respectively (Campbell *et al*., 2014).

In May 2012, the World Health Assembly declared WASH as an important component of an integrated control and elimination approach. This was based on the belief that WASH could reduce human water contact, thereby minimizing transmission (Grimes *et al*., 2015). Protection against *Schistosoma* infection could be achieved through the use of soap and endod, which are deleterious to cercariae, miracidia, and specific freshwater snails (Grimes *et al*., 2015). Among the activities that expose people to *Schistosoma* infections include laundry, bathing and swimming in cercarial contaminated water (Tayo *et a*l., 1980). Ensuring the availability of secure amenities, such as sinks and drainages, is crucial in the prevention of *Schistosoma* infections. Unavailability of safe water and such facilities may continue causing contacts with contaminated water (Grimes *et al*., 2015).

Sanitation is often insufficient or non-existent in *Schistosoma*-endemic poor areas (Champion *et al*., 2021). In communities where WASH interventions have been effectively implemented, there has been a significant decrease in the occurrence of both Schistosomiasis and STH. Studies have demonstrated that access to clean water can lead to a significant decline in infection rates, particularly in children who are most vulnerable to these parasitic infections (Madon *et al*., 2018).

Pit latrines are mostly used structures in SSA countries because of low cost and with logistically easy sanitation methods (World Health Organization & UNICEF, 2017). Excreta from the dug-out pit have the ability to leach into the groundwater if there is no padding. This has serious consequences for human health because it can lead to faecal enteric pathogen contamination of drinking water and other foodstuffs (Graham & Polizzotto, 2013). Despite the fact that WASH access and practices are linked to a lower risk of STH, trachoma, and schistosomiasis infection, WASH services in NTD prevention in endemic areas remain a challenge in Kenya. Except in some counties like Meru and Kajiado, improved water supplies are below 50% in most counties (Murkomen *et al*., 2019).

The impact of WASH on schistosomiasis and STH is undeniable. Availability of safe water, improved sanitation, and the promotion of proper hygiene behaviours are fundamental in reducing the transmission and burden of these neglected tropical diseases. Integrating WASH initiatives with existing control programs can lead to significant progress in the fight against Schistosomiasis and STH, ultimately leading to an improved well-being of affected communities, particularly children and women of childbearing age (Clasen, 2015).

2.9. Diagnosis and management of urinary schistosomiasis and soil-transmitted helminths

Urinary schistosomiasis is common in areas with freshwater bodies contaminated by parasite larvae. Diagnosis typically involves detecting *Schistosoma* eggs in urine samples, with microscopic examination being a common and cost-effective method. Additionally, serological tests that identify specific antibodies against *Schistosoma* antigens are used as supplementary diagnostic tools. Molecular techniques, like use of PCR, provide high sensitivity and specificity, especially in cases of low-intensity infections (Stothard *et al*., 2014).

The primary treatment for urinary schistosomiasis is the administration of praziquantel, an effective and safe anthelmintic drug. Praziquantel targets adult *Schistosoma* worms, inducing paralysis and their subsequent expulsion from the body. MDA initiatives, which include the provision of praziquantel to individuals at risk, have successfully decreased the occurrence of urinary schistosomiasis in locations where the disease is common. However, challenges like drug resistance and reinfection require ongoing efforts in surveillance, monitoring, and community engagement. For long-term control and prevention, it is essential to integrate drug treatment with health education and improved sanitation practices (Campbell *et al*., 2016).

During pregnancy, it is not recommended to administer praziquantel treatment, therefore it is typical for women to avoid taking drugs unless they are expressly prescribed as part of their prenatal care (De Rosa *et al*., 2022). There is a widespread belief that medicines can adversely affect the baby's development, leading to various reactions, perhaps caused by hormonal fluctuations observed in pregnant women. These perceptions often influence their decisions to avoid taking medications during pregnancy (Murenjekwa *et al*., 2021).

The standard method for diagnosing infections caused by STH parasites involves identifying their eggs in stool samples. This is typically done by performing microscopic examination of fecal smears, where the eggs can be visually detected and identified. However, newer diagnostic approaches, such as antigen detection tests and

PCR-based assays, offer improved sensitivity and specificity, facilitating more accurate and efficient detection of STH infections (Jourdan *et al.*, 2018).

In regions where soil-transmitted helminth (STH) infections are prevalent, every child who plays on the soil faces a considerable risk of getting infected. To ensure effective treatment for STH infections across all age groups, it is crucial to have sufficient evidence of infection before administering treatment. The diagnosis of STH infections commonly relies on identifying parasite eggs in faecal samples, making the Kato-Katz technique the gold standard method for examining intestinal helminths. This faecal thick smear technique is not only reliable but also easily adaptable for use in field studies, enabling efficient and accurate detection of STH infections in endemic areas (Shrestha *et al.*, 2021).

The Kato-Katz technique is particularly well-suited for diagnosing geohelminths that release eggs and are subsequently expelled in the stool. However, during examination, the egg count in faecal samples may vary from day to day due to fluctuations in helminth egg production. While the Kato-Katz technique demonstrates reasonably accurate laboratory diagnostic performance for detecting *A. lumbricoides* and *T. trichiura* infections, it exhibits lower sensitivity for detecting hookworm infections. This reduced sensitivity is attributed to the hookworm's delicate egg membrane, which undergoes rapid degeneration over time, potentially leading to underestimation or missed detection of hookworm infections during microscopic examination (Hailu & Abera, 2015).

Anthelmintic medicines, such as albendazole and mebendazole, are the main treatment for STH infections. These medications efficiently eradicate and remove the parasitic worms from the intestines. Similar to urinary schistosomiasis, Mass Drug Administration (MDA) initiatives have been initiated to distribute anthelmintic drugs to at-risk populations, with a particular focus on school-age children. However, it is essential to continuously monitor the effectiveness of drugs and the potential emergence of drug resistance in order to maintain successful long-term management strategies. Supplementary approaches, such as health education promoting hygiene practices, enhanced sanitation, and access to clean water, play a crucial role in preventing reinfection (Hong, 2018).

2.10. Conceptual framework

The conceptual framework presented below illustrates the interconnectedness between independent variables such as WASH factors and sociodemographic characteristics, with the prevalence and intensity of urinary schistosomiasis and STH being the dependent variables. The prevalence and intensity of these infections are affected by sociodemographic factors and WASH-related elements, such as access to safe water and the availability of enhanced water services, exposure to surface water, availability of managed sanitation services, utilization of unimproved sanitation facilities, and instances of open defecation. These WASH indicators and sociodemographic characteristics may either increase or decrease the prevalence and intensity of these infections (Figure 2.5).

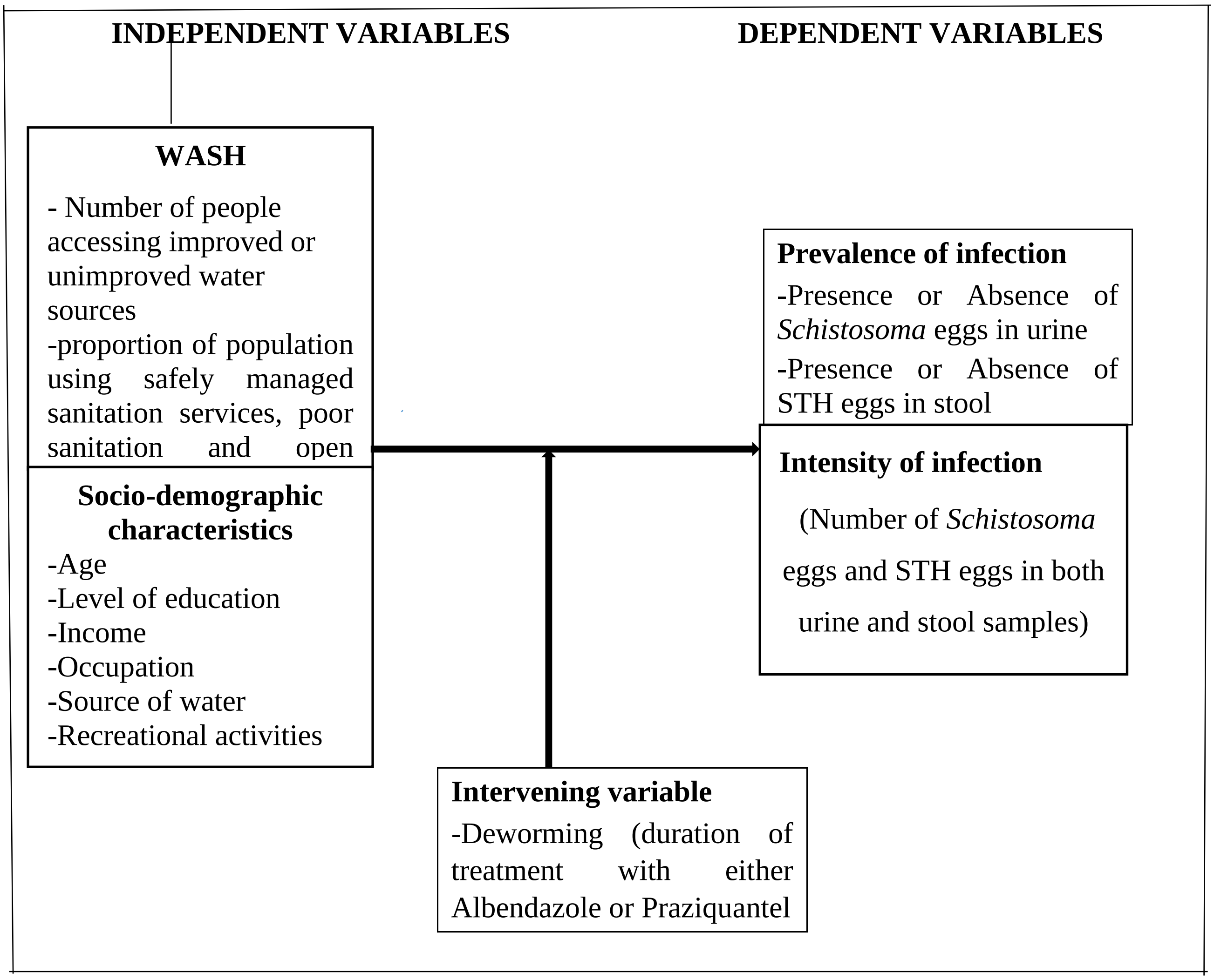


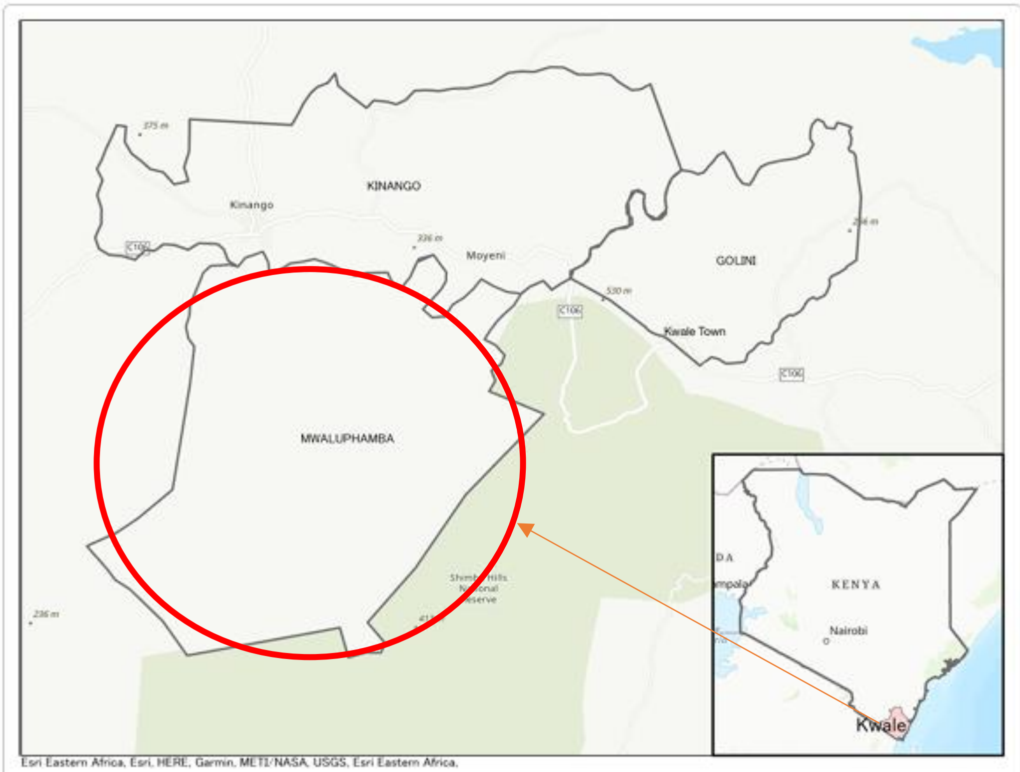
Figure 2.5. Conceptual framework

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study site

The study was conducted in Kwale County, situated in the southeastern region of Kenya's Coast Province. Tanzania is located to the south of the area, while the Indian Ocean borders it to the east. The latitude ranges from 3.558° to 4.675°S, and the longitude is from 38.452° to 39.663°E. The county spans an area of more than 8,295 square kilometers and is home to a population of 866,820 people (KNBS, 2019). Kwale County has an annual monsoon climate, characterized by dry and hot weather from January to April, and more moderate temperatures from June to August. The average temperature in the county is 24.2 ℃, which promotes the significant release of cercariae into the waters. The county has an annual rainfall ranging from 400 to 1,680 mm. Most inhabitants are subsistence farmers. Snails, the intermediate host of schistosomiasis, breed well in the arid regions, where there are many dams and seasonal streams, a case in Kwale County. The research focused on Matuga Sub-County, one of the five Sub-Counties in Kwale County. Sampling was done in four randomly selected villages from Mwaluphamba location, namely, Pengo, Mwele, Kibarani A and Kibarani B. The population in Matuga is approximately 194,250 people comprising of 95,831 and 98,419 males and females respectively. The Sub-County covers a land area of approximately 1032.4 square kilometres (KNBS, 2019).



Source: (Larson *et al*., 2021)

Figure 3.1. Map showing Mwaluphamba location

3.2. Study design

The data collection was conducted employing a community-based cross-sectional study design, from April to May 2022. The study design employed quantitative data collection techniques. The design was suitable for testing the association between the urinary schistosomiasis and soil-transmitted helminthiasis with other variables including the sociodemographic characteristics.

3.3. Study population

The study targeted all women aged between 15-49 years and residing in Mwele, Kibarani A, Kibarani B and Pengo villages and those who consented to participate in the study.

3.3.1. Inclusion and exclusion criteria

Women of reproductive age (15-49 years) who were permanent residents of the selected villages and consented to participate were included in the study. Permanent residency was determined through verification of participants' identification documents and community health records provided by local health authorities.

Pregnant women were excluded from the study. Pregnancy status was determined through self-reporting and confirmed using available antenatal clinic records. Those below and above the age bracket were also excluded from the study.

3.4. Sample size determination

The sample size was determined using Fishers formula for prevalence studies (Fisher, 1998). The study assumed the estimate prevalence of 45% found during a study done by (Kihara *et al*., 2011) where prevalence of urinary schistosomiasis was found to range between 0-91.3% among school children.

$$N = \frac{Z^2 P(1-P)}{d^2}$$

Where; N= minimum sample size, Z= Standard normal deviation 95% confidence interval (1.96), P= Estimated prevalence of schistosomiasis which is averaged at 45% that is, 0.45, d= Degree of precision (5% that is, 0.05). Based on these parameters, the sample size was calculated to be 380. To account for a potential 10% non-response rate, the sample size was adjusted upwards, resulting in a final sample size of 422 participants.

3.5. Sampling technique

Kwale County was purposively selected for this study due to the high endemicity of urinary schistosomiasis, with Matuga Sub-County chosen as the specific study area. Within Matuga, Mwaluphamba location, which consists of eight villages, was also purposively selected based on its high prevalence of urinary schistosomiasis. From these eight villages, four (Mwele, Kibarani A, Kibarani B, and Pengo) were randomly selected for sampling. The study employed a systematic random sampling, where every 3rd household in the selected villages was identified. From each household, women aged 15-49 years were randomly selected for participation, until when a sample size of 422 women was achieved.

Table distribution of the households in the study area

S/N	villages	No. of households	Selected households	Percentage	No. of Individuals	Percentage
1	Mwele	147	49	29.3	105	24.9
2	Kibarani A	102	34	20.4	105	24.9
3	Kibarani B	93	31	18.6	105	24.9
4	Pengo	160	53	31.7	107	25.3
	Total	**502**	**167**	**100%**	**422**	**100%**

3.6. Data collection

3.6.1. Parasitological methods

Respondents were given two labelled stool and urine containers bearing the subjects' specific identification code and asked to fill them with approximately 4g of stool and 30ml of urine. To preserve the stool sample 10 percent formalin was used. Urine specimen was collected between 10:00 am and 2:00 pm a convenient time for peak production of eggs by *S. haematobium* (Kihara *et al.*, 2011). A few drops of 10% formalin were added to the urine to preserve the integrity of the eggs before reaching the laboratory. A cool box was used to transport the samples to the laboratory for microscopic examination

3.6.1.1. Urine examination

Urine analysis was conducted using both the filtration technique and urine test strip (dipstick) method (Kosinski *et al.*, 2011). For the dipstick method, each urine sample was tested by dipping a reagent strip into it for approximately 2 seconds. The strip was then placed on a clean, level surface for interpretation, with the results compared to the reference provided on the container. The dipstick test was used to detect haematuria, leukocyturia, and proteinuria, which are markers for *S. haematobium* infection. In the filtration technique, after homogenizing each urine sample, approximately 10 milliliters were extracted into a syringe connected to a Swinnex filtering chamber. The urine was then passed through a 13mm Nytrel Ti 20HD filter to collect *Schistosoma* eggs. The membrane was carefully removed from the chamber using forceps, placed onto a microscope slide labeled with a specific identification code for each participant, and positioned for microscopic examination to detect the trapped eggs.

3.6.1.2. Stool examination

Stool samples were analysed within a time frame of 5 hours after collection from the participants. Each sample was processed using a double Kato-Katz technique *(Katz et al.*, 1972). For this procedure, pre-cut hydrophilic cellophane tape strips were immersed in a 10% glycerol-malachite green solution. Microscope slides designated for each stool sample were marked with the participant's identification code. The fecal material was then placed into a nylon screen and pressed through the sieve using a spatula to separate it from any debris. The screened feces were transferred to a template positioned centrally on a microscope slide, with the template hole fully filled and levelled with the sieved fecal material. A cellophane square film, soaked in 3% aqueous malachite green and glycerol for 24 hours to enhance the visibility of soil-transmitted helminth (STH) eggs, was placed on the slide containing the stool specimen. The slide was then inverted against another slide to evenly spread the fecal specimen under the cellophane. Finally, each slide was systematically examined at X400 magnification for the presence of STH ova.

3.6.2. Questionnaire

A standardized questionnaire was administered to study participants to gather sociodemographic data and information on WASH practices (Cheung, 2021). This instrument was pre-tested prior to the actual data collection period. The questionnaire had unique identification codes to ensure consistency with the collected samples. Trained personnel verbally interviewed respondents and filled responses where applicable. The variable results in the coded questionnaire were compared with the matching examined slides of faecal and urine samples to investigate the relationship between urinary schistosomiasis and STH evidence, egg count and socio-demographic information.

3.6.2.1 Reliability of the questionnaire

A pre-test was conducted on a population comparable to the target population. Questionnaires were pre-tested in Kwale town where 23 women of reproductive age were randomly selected to fill their responses. The filled questionnaires were then coded and analyzed using Microsoft Excel. To run a reliability test, a two-factor Anova without replication was done and the results used to calculate Cronbach’s alpha value (Johnson, 2017). The survey included 22 items in one subscale which gave a Cronbach’s alpha value at $\alpha = 0.706969$. For the measurement of internal consistency, any value that lies between $\alpha = (0.7)$ to $\alpha = (0.9)$ indicates that the questionnaire is acceptable. In this pilot study a 0.706969 Cronbach’s alpha value indicated that the research instrument is acceptable and can be relied on to make valid and reliable conclusions.

3.6.2.2 Validity of the questionnaire

Validity pertains to the precision and authenticity of the data generated concerning the concept under investigation, the individuals or entities being examined, and the methodologies employed (Heale & Twycross, 2015). Before the pilot study commenced, the questionnaire was assessed for both content and face validity. Face validity was achieved by presenting the questionnaire to supervisors and colleagues in order to assess the extent to which the items accurately represented the study's objectives. Content validity was guaranteed by reviewing literature on current policies from the Ministry of Health to align with national guidelines. Following these steps, the questionnaire was deemed valid for obtaining the desired information regarding the study's objectives.

3.7. Data management and analysis

The data collected were entered into a Microsoft excel spreadsheet and cleaned before analysis using SPSS statistical software, version 25.0. Descriptive statistics, including frequency percentages, and mean, were computed for the demographic characteristics of the study participants. Prevalence was determined for both urinary schistosomiasis and STH among consenting participants. This was calculated by dividing the count of women with either STH or urinary schistosomiasis by the total number of individuals who were tested for both infections. To determine the number of eggs per gram for STH, the counted eggs were multiplied by a standard conversion factor of 24.

According to WHO guidelines, hookworm infection intensity is grouped as light (1-1,999 EPG), moderate (2,000-3,999 EPG), and heavy (≥4,000 EPG). *T. trichiura* infection is classified as light (1-999 EPG), moderate (1,000-9,999 EPG), and heavy (≥10,000 EPG), while *A. lumbricoides* infection is categorized as light (1-4,999 EPG), moderate (5,000-49,999 EPG), and heavy (≥50,000 EPG), while urinary schistosomiasis intensity was classified as light (1-49 eggs/10ml) and heavy (≥50 eggs/10ml) (WHO, 1998). The chi-square (χ^2) test was used to compare prevalence estimates and categorical sociodemographic characteristics. In instances where the expected frequencies were less than 5, Fisher's exact chi-square was utilized. A normality test was conducted, revealing a non-normal distribution of egg counts. Therefore, the Kruskal-Wallis H-test was used to compare median egg counts across groups, such as education level. Univariable regression analysis was conducted to assess the association between WASH factors, urinary schistosomiasis and soil-transmitted helminthiasis. The candidate variables for multivariable logistic regression were chosen based on the p-value results obtained during the univariable analysis, with a significance level of $p \leq 0.25$. Statistical significance was defined at $p \leq 0.05$.

3.8. Quality control

Samples were collected using sterile techniques and analyzed under the supervision of a highly skilled and experienced laboratory technologist. For additional quality assurance, a senior technician from the parasitology department re-evaluated the Kato-Katz thick smears and urine slides. After examination, the urine and stool samples were disposed based on the standard operating procedures.

3.9. Ethical consideration

The research received ethical approval from the Institutional Review Board of Kenyatta National Hospital (approval Number: P453/06/2021). Permission to undertake the research within the community was obtained from the Kwale County Ministry of Health (Reference Number: KWL/6/5/CEC/39/VOL.1/45).

3.10. Consenting of study participants

Participation in the study was voluntary, and written consent was obtained from all participants before sample collection. For individuals aged 18 and above, consent forms were signed directly by the participants. For those under 18, informed consent was obtained from their parents or legal guardians, allowing their participation.

Interviews were conducted in Kiswahili through an online questionnaire to accommodate individuals who were unable to read. Participants were assured that their data would be kept confidential and used solely for the study's objectives.

3.12 COVID-19 protocols

Ministry of Health measurements on COVID-19 pandemic were observed. This included wearing of face masks and hand sanitizing for both respondents and the interviewers. Crowds were avoided as data collection was done at each individual's household.

CHAPTER FOUR

RESULTS

4.1. Introduction

This chapter outlines the results of data collected in Mwaluphamba, between April and May 2022, focusing on the prevalence, intensity, and factors related to WASH that contribute to urinary schistosomiasis and STH infections among women of reproductive age.

4.2. Socio-demographic characteristics of the study participants

A total of 422 individuals were included in the research from 167 households resulting in a 100% response rate. This was a result of the previous mobilization of the research by Community Health Volunteers (CHVs). The participants were aged between 15 and 49 years, with 236 (55.9%) falling within the 15-19 age range. A majority of the participants, 260 (61.6%), were not married, while 161 (38.2%) were married. According to the level of education, 280 (66.4%) had attained primary level of education, 86 (20.4%) secondary education, 2 (0.5%) tertiary education while 54 (12.8%) had not attended any form of training. In terms of occupation, most participants, 244 (57.8%), were students, followed by 163 (38.6%) who were farmers, 12 (2.8%) who were traders, and only 3 (0.7%) had formal employment. Out of the surveyed individuals, 275 people, constituting 65.2% of the total, were aware of urinary schistosomiasis and soil-transmitted helminthiasis. Conversely, 139 individuals, accounting for 32.9%, had no knowledge about these diseases. The primary water source for household use among the participants predominantly included surface water, utilized by 372 individuals (88.2%), followed by standpipes 89 individuals (21.1%), unprotected wells 83 individuals (19.7%), and boreholes 39 individuals (9.2%). Collecting water was the main reason for water contact among the study participants 396 (93.8%), followed by crossing to go to a place 354 (83.9%), washing 347 (82.2%), bathing 88 (20.9%) and lastly swimming 3 (0.7%). 407 (96.4%) have latrine in their home while 15 (3.6%) have no latrine at their homes (Table 1).

Table 1. Sociodemographic characteristics of the study participants.

Variable	No. of the examined	Percentage (%)
Village		
Kibarani A	105	24.9
Kibarani B	105	24.9
Mwele	105	24.9
Pengo	107	25.3
Age groups, years		
15-19	236	55.9
20-29	80	19.0
30-39	59	14.0
40-49	47	11.1
Marital status		
Married	161	38.2
Not married	260	61.6
Divorced/separated	1	0.2
Level of education		
No formal education	54	12.8
Primary	280	66.4
Secondary	86	20.4
Tertiary	2	0.5
Occupation		
Student	244	57.8
Farmer	163	38.6
Trader	12	2.8
Employed	3	0.7
Aware of disease		
No idea	139	32.9
Heard	275	65.2
Know	8	1.9
Reason for water contact		
Crossing to place	354	83.9
Collecting water	396	93.8

Bathing	88	20.9
Washing	347	82.2
Swimming	3	0.7
Have latrine		
No	15	3.6
Yes	407	96.4
Source of water		
Surface water		
No	50	11.8
Yes	372	88.2
Standpipe water		
No	333	78.9
Yes	89	21.1
Borehole		
No	383	90.8
Yes	39	9.2
Unprotected well		
No	339	80.3
Yes	83	19.7

4.3. Prevalence of urinary schistosomiasis and Soil-transmitted helminthiasis

Out of the 422 participants tested for urinary schistosomiasis, 20 tested positive, resulting in a total prevalence of 4.7% (95% CI: 2.8%-6.9%). The prevalence of urinary schistosomiasis was higher in Pengo (6.5%) compared to Mwele, Kibarani B and Kibarani A with the prevalence of 5.7%, 4.8% and 1.9% respectively. There were no statistically significant differences observed in the prevalence of urinary schistosomiasis in the four villages (F=3.056, p=0.403). Based on the age groups, women aged 15-19 years (15, 6.4%) showed highest infection rate, followed by 20-29 years (3, 3.8%), 40-49 years (2, 4.3%) whereas those aged 30-39 years showed no infection. There was no statistically significant variation in the prevalence of urinary schistosomiasis across different age groups (F=4.454, p=0.196). Marital status, occupation, and knowledge about urinary schistosomiasis did not show statistically significant associations with urinary schistosomiasis prevalence. However, education level was significantly associated with urinary schistosomiasis prevalence (F=7.280, p=0.049), with women having no formal education exhibiting the highest prevalence (9.3%), followed by those with primary (4.3%) and secondary (3.5%) education, while no infections were observed among those with tertiary education.

The total prevalence of STH infection was at 4.5% (19/422, 95% *CI* 2.6%-6.7%), with the hookworms (3.6%, 95% *CI* 1.9%-5.5%) being the main species, followed by *T. trichiura* (0.9%, 95% *CI* 0.01%-1.90%), whereas *A. lumbricoides* showed no infection. Based on the villages, Kibarani A showed a slightly high prevalence of hookworms (5.7%, 6/422) followed by Mwele (3.8%), Kibarani B (2.9%) and Pengo (1.9%). There was no statistically significant variation in the prevalence of STH across different sociodemographic factors except for *T. trichiura* that showed a significant difference between its prevalence and knowledge about the disease (F=7.321, p=0.032). There were no cases of multiple infections with both *S. haematobium* and STH (Table 2).

There was no statistically significant association between Albendazole treatment and STH prevalence (p = 0.42). Similarly, there was no statistically significant association between Praziquantel treatment and *S. haematobium* prevalence (p = 0.36). Majority of the study participants had dewormed approximately a year ago. The recommended and effective deworming schedule is every 3 months, which ensures a more consistent reduction in the parasite load and interrupts the transmission cycle. Deworming annually may be insufficient to maintain low infection rates, as reinfection and continued exposure can occur, leading to the persistence of these diseases in the population.

Table 2. Prevalence of urinary schistosomiasis and soil-transmitted helminth in relation to sociodemographic characteristics.

Categories	***S. haematobium, n*** **(%)**	**Fisher's exact test (p-values)**	**hookworm, n (%)**	**Fisher's exact test (p-values)**	***T. trichiura,*** **n (%)**	**Fisher's exact test (p-values)**
Village						
Kibarani A	2 (1.9)		6 (5.7)		0 (0.0)	
Kibarani B	5 (4.8)		3 (2.9)		1 (1.0)	
Mwele	6 (5.7)		4 (3.8)		2 (1.9)	
Pengo	7 (6.5)	*0. 403*	2 (1.9)	*0.450*	1 (0.9)	*0.761*
Age groups, years						
15-19	15 (6.4)		7 (3.0)		1 (0.4)	
20-29	3 (3.8)		2 (2.5)		1 (1.3)	
30-39	0 (0.0)		5 (8.5)		0 (0.0)	
40-49	2 (4.3)	*0.196*	1 (2.1)	*0.235*	2 (4.3)	*0.099*
Marital status						
Married	5 (3.1)		7 (4.3)		2 (1.2)	
Not married	15 (5.8)		8 (3.1)		2 (0.8)	
Divorced/separated	0 (0)	*0.282*	0 (0.0)	*0.605*	0 (0.0)	*0.642*
Level of education						
No formal education	5 (9.3)		2 (3.7)		0 (0.0)	
Primary	12 (4.3)		10 (3.6)		3 (1.1)	
Secondary	3 (3.5)		3 (3.5)		1 (1.2)	
Tertiary	0 (0.0)	***0.049****	0 (0.0)	*0.174*	0 (0.9)	*0.861*
Occupation						
Student	14 (5.7)		8 (3.3)		2 (0.8)	
Farmer	6 (3.7)		6 (3.7)		2 (1.2)	
Trader	0 (0.0)		1 (8.3)		0 (0.0)	
Employed	0 (0.0)	*0.639*	0 (0.0)	*0.526*	0 (0.0)	*0.710*
Aware of disease						
No idea	7 (5.0)		4 (2.9)		2 (1.4)	
Heard	13 (4.7)		11 (4.0)		1 (0.4)	
Know	0 (0.0)	*0.808*	0 (0.0)	*0.837*	1 (12.5)	***0.032****

***Significant variables at 5% significance level**

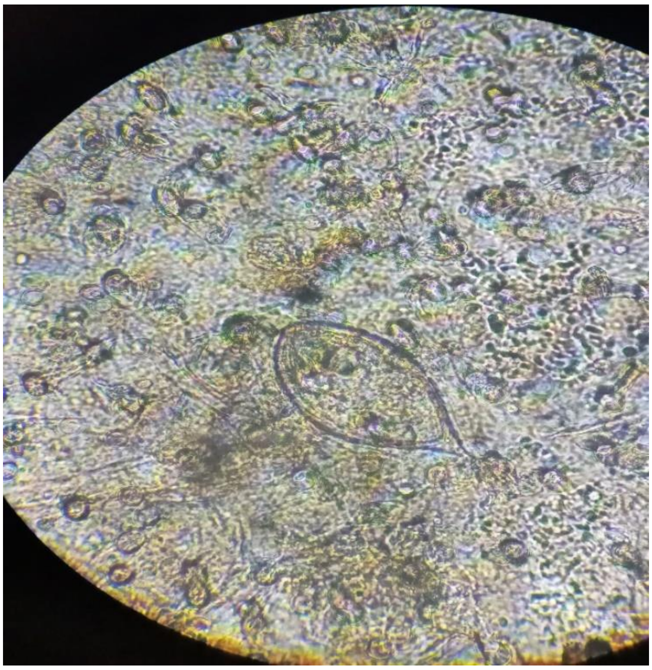


Plate 4.1. A microscopic image of *S. haematobium* egg

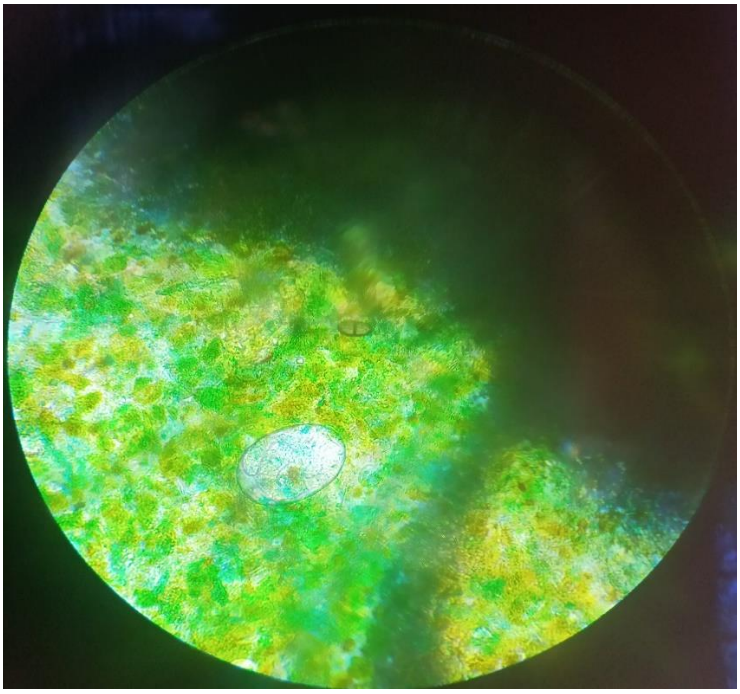


Plate 4.2. A microscopic image of hookworm egg

4.4. Prevalence of haematuria, proteinuria and leukocyturia

Table 3 represents the prevalence of three key urinary symptoms (haematuria, proteinuria, and leukocyturia) and their association with *S. haematobium* infection. Overall, 29 (6.9%) individuals had haematuria, 37 (8.8%) had proteinuria while 29 (6.9%) had leukocyturia. This study revealed statistically significant associations between *S. haematobium* infection and haematuria, proteinuria, leukocyturia (Table 3).

Table 3. Prevalence of hematuria, proteinuria, and leukocyturia in relation to *S. haematobium* infection

Condition	**Category**	**Total (n=422, %)**	***S. haematobium* infection positive (n=20)**	***S. haematobium* Negative (n=402)**	**Fisher's exact test (p-values)**
Haematuria	No	393 (93.1)	0	393	
	Yes	29 (6.9)	20	9	**<0.001**
Proteinuria	No	385 (91.2)	0	385	
	Yes	37 (8.8)	20	17	**<0.001**
Leukocyturia	No	393 (93.1)	7	386	
	Yes	29 (6.9)	13	16	**<0.001**

4.5. Infection intensity of urinary schistosomiasis and STH among women of reproductive age

Among the research participants, the intensity of urinary schistosomiasis varied from 1 to 120 eggs per 10 mL of urine, with a median total egg count of 18.45 eggs per 10 mL. Based on the WHO categorization of *S. haematobium* infection intensities, 18 (4.3%) had light infection intensities (1-49 eggs/10 mL), while 2 (0.5%) individuals had heavy infection intensities (≥ 50 eggs/10 mL of urine). The parasite median egg load was high in Kibarani B (20.00 eggs/10 mL, 95% *CI* 1.00- 120.00) compared to Mwele (13.50 eggs/10 mL, 95% *CI* 1.00- 25.50), Pengo (9.00 eggs/10 mL, 95% *CI* 5.00-17.00) and Kibarani A (3.50 eggs/10 mL, 95% *CI* 1.00- 6.00), though there were no significant differences observed p=0.390). In terms of the age groups, those aged 20-29 years had slightly higher median infection intensities (20.00 eggs/10 mL, 95% *CI* 15.00-60.00) compared to other age groups but the differences were also not statistically significant (p=0.079). In summary, there was no significant differences in median egg counts across villages (p=0.390), age groups (p=0.079), education level (p=0.703), occupation (p=0.741), marital status (p=0.606) and knowledge about urinary schistosomiasis (p=0.283) (Table 4).

Table 4. Association between the intensity of *S. haematobium* infection and sociodemographic characteristics.

Category	No. of infections	Intensity of infection		Median egg count (95% *CI*)	p-value
		Light, n (%)	Heavy, n (%)		
Overall Median US	20	**18 (4.3)**	**2 (0.5)**	**18.45 (9.15-31.40)**	
Village					
Kibarani A	2	2 (1.9)	0 (0)	3.50 (1.00- 6.00)	
Kibarani B	5	3 (2.9)	2 (1.9)	20.00 (1.00-120.00)	
Mwele	6	6 (5.7)	0 (0)	13.50 (1.00-25.50)	
Pengo	7	7 (6.5)	0 (0)	9.00 (5.00-17.00)	*0.390*
Age group, years					
15-19	15	14 (5.9)	1 (0.4)	9.00 (3.00-18.50)	
20-29	3	2 (2.5)	1 (1.3)	20.00 (15.00- 60.00)	
40-49	2	2 (4.3)	0 (0)	7.50 (6.00-9.00)	*0.079*
Marital status					
Married	5	5 (3.1)	0 (0)	9.00 (1.00-29.00)	
Not married	15	13 (5.0)	2 (0.8)	10.00 (4.50-20.00)	*0.606*
Level of education					
No formal education	5	5 (9.3)	0 (0)	15.00 (6.00-29.00)	
Primary	12	11 (3.9)	1 (0.4)	7.50 (3.00-17.00)	
Secondary	3	2 (2.3)	1 (1.2)	20.00 (1.00-60.00)	*0.703*
Occupation					
Student	14	12 (4.9)	2 (0.8)	9.50 (3.00-20.00)	
Farmer	6	6 (3.7)	0 (0)	12.00 (3.50-28.91)	*0.741*
Aware of disease					
No idea	7	6 (4.3)	1 (0.7)	15.00 (6.00-67.42)	
Heard	13	12 (4.4)	1 (0.4)	9.00 (3.00-17.00)	*0.283*

The total geometric mean egg per gram (EPG) for STH was 56.16 egg/gram and 48.48 egg/gram for *T. trichiura* and hookworms, respectively. *A. lumbricoides* showed no infection. The intensities of hookworms ranged from 24 to 960 EPG while those of *T. trichiura* ranged from 24 to 144 EPG. In accordance with the WHO classification of STH infection intensities, all intensities were light with no moderate and heavy infection intensities observed (Table 5).

Table 5: Intensity of STHs infection among women of reproductive age in the four (4) villages

STH parasite species	Geometric mean (Egg/gram)	Number infected (n, %)	Intensity of infection		
			Light (n, %)	Moderate (n, %)	Heavy (n, %)
Trichuris trichuira	56.16egg/gram	4 (0.94)	4 (0.94)	0 (0)	0 (0)
Hookworm	48.48egg/gram	15 (3.6)	15 (3.6)	0 (0)	0 (0)

4.6. WASH factors associated with urinary schistosomiasis and soil-transmitted helminthiasis

In the univariable logistic regression, $p \leq 0.25$ was used for the selection of variables in the multivariable analysis. The multivariable analysis of WASH factors related to urinary schistosomiasis identified the groups with high odds of infection. Women without access to latrine showed increased risk of urinary schistosomiasis (a*OR* 15.70, 95% *CI* 4.21-58.53, p<0.001) compared to those with latrines. Women using surface water as source of water (a*OR* 1.03, 95% *CI* 0.23-1.43, p=0.010) showed increased risk of getting urinary schistosomiasis. Women who crossed the river to go to a place (a*OR* 1.13, 95% *CI* 0.29-1.61, p=0.006) also showed increased risk of getting urinary schistosomiasis. On the contrary, use of standpipe as the source of water (a*OR* 0.02, 95% *CI* 0.001-0.33, p=0.009) showed reduced risk of being infected with *S. haematobium*. Lack of latrine, surface water and crossing the river to go to a place are statistically significant risk factors associated with infection with *S. haematobium*. Use of stand piped water was found to be protective against urinary schistosomiasis (Table 6).

Table 6. Univariable and multivariable logistic regression for WASH factors associated with urinary schistosomiasis.

Factor	**Categories**	***OR* (95% *CI*)**	**P-value**	**a*OR* (95% *CI*)**	**P-value**
Age group, years	15-19	1		1	
	20-29	0.57 (0.16-2.04)	0.390	0.86 (0.28-2.64)	0.307
	40-49	0.65 (0.15-2.96)	0.583	0.73 (0.29-1.61)	0.239
What used to wash hands	Soap and water	1		1	
	Water only	1.97 (0.79-4.91)	0.148	1.32 (0.43-4.04)	0.624
Availability of latrine	No	13.07 (3.97-42.99)	**<0.001***	15.70 (4.2-58.5)	**<0.001***
	Yes	1		1	
Source of water	**Surface water**				
	No	1		1	
	Yes	1.39 (0.14-2.12)	0.079	1.03 (0.23-1.43)	**0.010***
	Borehole				
	No	1			
	Yes	1.74 (0.49-6.22)	0.393	−	−
	Unprotected well				
	No	1			
	Yes	1.81 (0.67-4.86)	0.340	−	−
	Standpipe				
	No	1		1	
	Yes	0.19 (0.02-1.40)	0.102	0.02 (0.001-0.34)	**0.006***
Reason for contact with water source	**Crossing river**				
	No	1		1	
	Yes	1.42 (0.15-2.13)	0.085	1.13 (0.29-1.61)	**0.009***
	Bathing				
	No	1			
	Yes	1.67 (0.62-4.49)	0.307	−	−
	Collecting water				
	No	1		1	
	Yes	0.33 (0.09-1.20)	0.093	1.18 (0.11-12.36)	0.891
	Washing clothes				
	No	1			
	Yes	0.86 (0.28-2.64)	0.790	−	−
Urination site	Nearby bush	1		1	
	Around water source	0.35 (0.09-1.27)	0.107	0.69 (0.09-5.05)	0.713
Defecation site	Nearby bush	1			
	Around water source	1.29 (0.29-5.83)	0.740	−	−

***Significant variables at 5% significance level; OR=Odds ratio (univariable logistic regression); aOR=Adjusted odds ratio (multivariable logistic regression); 95% CI= 95% Confidence Interval, WASH: water, sanitation, and hygiene; -: variables not included in multivariable logistic regression (*P*≤0.25).**

In the univariable regression analysis, the act of defecating around the water source showed a statistically significant association with the prevalence of STHs (OR 4.345, 95% CI 1.466-12.883, p=0.008). However, this did not significantly predict STH infection by women of reproductive age in multivariable logistic regression. Collecting water as a reason for water contact (aOR 0.184, 95% CI 0.035-0.966) was statistically and independently associated with reduced risk of STHs infection (p=0.045) (Table 7).

Table 7. Univariable and multivariable logistic regression for WASH factors associated with soil-transmitted helminthiasis.

Factor	Categories	OR (95% CI)	P-value	aOR (95%CI)	P-value
Age group, years	15-19	1		1	
	20-29	1.11 (0.29-4.29)	0.879	1.01 (0.25-4.03)	0.991
	30-39	2.64 (0.83-8.39)	0.100	2.78 (0.83-9.33)	0.099
	40-49	1.94 (0.50-7.61)	0.340	1.60 (0.39-6.60)	0.513
Wash hands	**After defecation**				
	No	1			
	Yes	0.69 (0.27-1.73)	0.426	–	–
	Before eating				
	No	1			
	Yes	1.02 (0.38-2.73)	0.977	–	–
	Hands noticeably dirty				
	No	1			
	Yes	0.75 (0.24-2.32)	0.615	–	–
What used to wash hands	Soap and water	1			
	Water only	1.15 (0.46-2.89)	0.768	–	–
Source of water	**Surface water**				
	No	1		1	
	Yes	0.36 (0.12-1.05)	0.061	3.02 (0.11-85.23)	0.516
	Borehole				
	No	1		1	
	Yes	2.72 (0.86-8.63)	0.090	1.35 (0.04-0.97)	0.821
	Unprotected well				
	No	1			
	Yes	0.47 (0.12-2.07)	0.316	–	–
	Standpipe				
	No	1			
	Yes	1.75 (0.65-4.75)	0.270	–	–
Reason for contact with water source	**Collecting water**				
	No	1		1	
	Yes	0.21 (0.06-0.68)	**0.009***	0.18 (0.04-0.97	**0.045***
	Washing clothes				
	No	1			
	Yes	0.59 (0.21-1.69)	0.324	–	–
Defecation site	Nearby bush	1		1	
	Around water source	4.35 (1.47-12.88)	**0.008***	4.19 (0.49-35.55)	0.189

***Significant variables at 5% significance level; OR=Odds ratio (univariable logistic regression); aOR=Adjusted odds ratio (multivariable logistic regression); 95% CI= 95% Confidence Interval, WASH: water, sanitation, and hygiene; -: variables not included in multivariable logistic regression ($P \leq 0.25$).**

CHAPTER FIVE

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1. Discussion

Schistosomiasis and soil-transmitted helminthiasis remain major public health issues in many developing nations, especially among rural communities in Sub-Saharan Africa, including Kenya. The objective of this research was to assess the epidemiology of urinary schistosomiasis and soil-transmitted helminthiasis among women of reproductive age (WRA) in Mwaluphamba, Kwale County, Kenya. The overall prevalence of urinary schistosomiasis and STH among women of reproductive age (WRA) in the selected villages were 4.7% and 4.5%, respectively. Thus, out of the three species of STH, hookworm was the dominant followed by *T. trichiura* whereas this study found no infections as a result of *A. lumbricoides*.

The prevalence of urinary schistosomiasis was lower compared to a study done among people of different ages in Kwale which revealed increased rates of *S. haematobium* infection among participants residing in the catchment areas of Mwachinga, Mwaluphamba, and Bilashaka Dispensaries, with prevalence rates of 11.96%, 20.96%, and 22.13% respectively. However, the catchment area of Mbuwani Dispensary exhibited a lower prevalence of 1.13% compared to the present study (Kaiglová *et al*., 2020). The prevalence of urinary schistosomiasis and STH in this research was comparatively lower than a study conducted in specific schools within this county, where the prevalence rates of *S. haematobium*, hookworm, and *T. trichiura* among school-going children were reported as 33.2%, 26.1%, and 1.6%, respectively (Chadeka *et al*., 2017). A study done from Bilashaka, Mwaluphamba, Mwachinga, and Dumbule villages, reported a prevalence of 5.6% for STH, this was slightly above the STH prevalence reported during this study (Jeza *et al*., 2022).

In a research conducted in Mwaluphamba, Kwale County, in 2011, significant prevalence of hookworm infection (41.7%) was documented among adult participants (Njenga *et al*., 2011). Since this study was done more than 13 years ago, the drastic reduction for hookworms infection among the adults observed recently could be attributed to possible improved sanitation, health education and behavioural change coupled with improved use of latrines and water (Jeza *et al*., 2022). Possible explanations for the reduced prevalence in the current study compared to earlier studies could be attributed to seasonality in schistosomiasis transmission and differences in geographical locations and possibly treatment. The current study was conducted during the rainy season, which may account for the reduced prevalence observed. This is consistent to a study carried out in Southern Mauritania that showed significantly higher schistosomiasis infections during dry season as compared to rainy season (Gbalégba *et al*., 2017). Low prevalence in this study could also be attributed to both school based and community based MDA which is usually done once every year (Kaiglová *et al*., 2020).

There was a notable increase in the prevalence of urinary schistosomiasis among those aged 15-19 years compared to other age brackets. This agrees with previous research carried out in Cameroon, which revealed a high prevalence of urinary schistosomiasis in this particular age group of women (Behnke *et al*., 2003; Ntonifor *et al*., 2012). This may be because they are the most physically active age group and engage in the majority of outdoor activities, including swimming in contaminated water and obtaining water from rivers. This study found that surface water was the main source of water in the sampled villages hence high risk of exposure. Hookworms and *T. trichiura* infections were found to be high in the age groups between 30-39 years and 40-49 years respectively. This was therefore not consistent with the observation by (Jeza *et al*., 2022) that the prevalence of STH decreases with age since the current study found a variation of prevalence among the age groups. One possible explanation is regional or geographic differences in the prevalence of STH infections. Different areas may have varying levels of sanitation, hygiene practices, and exposure to contaminated soil, which can influence the transmission of these parasites. For instance, a study in coastal Kenya indicated that adults had a higher prevalence of hookworm infection as opposed to children, most likely due to increased environmental exposure over time (Halliday *et al*., 2019). The study findings of peak *Trichuris trichiura* and hookworm infection prevalence between 30-49 years old may represent greater exposure risks unique to the local environment. The high prevalence among adults emphasizes the need for extended Mass Drug Administration and other control treatments in this population subgroup, not just school-aged children.

The significant association observed between education level and urinary schistosomiasis (US) prevalence in this study, with the highest prevalence among women with no formal education aligns with findings from several previous studies. For instance, a study by M'Bra *et al*. (2018) reported comparable results, indicating a higher prevalence of schistosomiasis among individuals with lower educational attainment (M'Bra *et al*., 2018). Additionally, a 2016 study in Côte d'Ivoire revealed that adults with no formal education had over three times higher odds of *S. mansoni* infection compared to those with secondary or higher education. The researchers hypothesized that more years of schooling could enhance hygiene practices, health knowledge, and healthcare seeking behaviors to minimize schistosomiasis transmission (Assaré *et al.*, 2016). This pattern could be attributed to several interconnected factors. Firstly, individuals with lower levels of education may have limited access to health education and awareness campaigns, reducing their knowledge about schistosomiasis transmission and prevention. Additionally, lower-educated individuals might be at a higher risk of infection due to their involvement in activities such as agricultural labor or household chores, which often expose them to contaminated water sources.

Among the 29 women of reproductive age who tested positive for haematuria, only 20 individuals (69.0%) showed the presence of *S. haematobium* eggs in their urine. It's noteworthy that not all instances of haematuria were associated with the presence of *Schistosoma* eggs in the urine, which aligns with findings from previous studies (Opara *et al*., 2021). Some cases of haematuria reported in this study were as a result of menstrual blood from some study participants. Of the 37 women that were positive for proteinuria, 20 (54.1%) had *S. haematobium* eggs in their urine. The statistical significance between *S. haematobium*, haematuria, proteinuria and leukocyturia implies that these symptoms may serve as diagnostic signs of *Schistosoma* infection. A similar result was reported in Senegal (Meurs *et al*., 2013) and Ghana (Boye *et al*., 2016). Similarly, a study in Nigeria discovered that hematuria and proteinuria have a high level of specificity and sensitivity for detecting *S. haematobium* infection, demonstrating their reliability as markers of urogenital schistosomiasis (Atalabi *et al*., 2017). Furthermore, studies in Zimbabwe reported concurrent hematuria, proteinuria, and *S. haematobium* egg counts, supporting macrohematuria and microhematuria as good predictors of infection (Midzi *et al*., 2010). These findings underscore the value of urinary symptoms as screening tools for *S. haematobium* infection, while also highlighting the need for caution in their interpretation due to the potential for false positives and negatives.

The morbidity of urinary schistosomiasis is linked to the intensity of the infection (Ojo *et al*., 2021). The study participants' infection intensities of urinary schistosomiasis ranged from 1 to 120 eggs/10ml of urine, with an overall median egg count of 18.45 eggs/10ml. Based on the World Health Organization's classification for *S. haematobium* infection intensity levels, the overall intensity observed in this study fell within the light infection category. However, two individuals, accounting for 0.5% of the study population, showed heavy infection levels (≥ 50 eggs/10ml of urine). The median egg count observed in this research was slightly lower than that found in a similar study involving women of reproductive age in Tanzania, where egg counts were 8 to 38 eggs per 10 millilitres of urine, and a total geometric mean of 19.5 eggs per 10 millilitres of urine (Rite *et al*., 2020). This suggests that while most residents in the study area may experience mild symptoms associated with light infections, there is still a small but significant portion of the population at risk for severe morbidity due to heavy infections. This underscores the need for targeted interventions to reduce the infection intensity among the population to prevent potential long-term health complications.

The median egg count in this study is also considerably lower than that reported in Kwara state, Nigeria, where the mean egg count was 127.9 eggs/10ml of urine (Abdulkareem *et al.*, 2018). The differences in urinary schistosomiasis infection intensity between the studied regions can be primarily attributed to geographical variations in transmission dynamics and local water contact behaviours. Additionally, variations in the implementation and effectiveness of schistosomiasis control programs and the age distribution of the populations studied may contribute to differences in infection intensity. All cases of STH among women in this study were defined as light infections. A study conducted from January to December 30, 2017, among school children in the Gurage zone of southern Ethiopia, revealed similar findings, where Hookworm, *E. vermicularis*, *Taenia* species, *A. lumbricoides*, *T. trichiura*, and *H. nana* were all classified as light infections (Weldesenbet *et al.*, 2019).

The analysis of WASH-related factors indicates that women lacking latrines had increased odds of urinary schistosomiasis infection compared to those with access to a latrine. This aligns with findings from a study conducted by (Sady *et al*., 2013), which demonstrated a significant association between the absence of a latrine in the household and the prevalence of urinary schistosomiasis. Individuals lacking latrines in their house might have a tendency of defecating or urinating near water bodies, therefore increasing the risk of *Schistosoma* transmission. The statistically significant associations between reliance on surface water sources, and the practice of crossing rivers and *S. haematobium* infection align with findings from previous studies. For instance, a study by Mutsaka-Makuvaza *et al*. (2019) conducted in semi-arid areas of Makonde rural district, Zimbabwe, reported similar results, highlighting that the dependence on potentially contaminated surface water bodies were key risk factors for *S. haematobium* infection. This consistency in findings can be attributed to the fact that *S. haematobium* transmission primarily occurs through contact with infested freshwater sources. These findings underscore the critical importance of sanitation infrastructure and access to safe water sources in preventing *S. haematobium* infection in endemic areas (Mutsaka-Makuvaza *et al.*, 2019).

Use of stand pipe as the source of water was found to be protective against urinary schistosomiasis since individuals using stand pipe had reduced odds of infection. A similar finding was observed by (Balen *et al.*, 2011), where it was found that the transmission of urinary schistosomiasis is positively linked to the absence of using a tap as a source of drinking water. Similarly, in a study conducted in Yemen, it was discovered that children who accessed unsafe drinking water sources had notably greater chances of contracting schistosomiasis compared to those residing in homes with piped water supply (Sady *et al.*, 2013). Stand pipe minimises water contact with the cercarial infested water bodies hence reducing the risk of *Schistosoma* infection.

Collecting water as a reason for contact with water source had reduced risk of infection by soil-transmitted helminthiasis. This aligns with findings from a systematic review and meta-analysis study that investigated the relationships between improved WASH practices and STH infection. The study concluded that access to water and related practices were typically linked to reduced odds of STH infection (Strunz *et al.*, 2014). Consistent with the results of this research, another study illustrated that enhanced WASH practices resulted in a significant reduction in the prevalence of STH, notably *A. lumbricoides* and hookworms (Grimes *et al*., 2016). The reduced odds of infection with collecting water in this study could be attributed to the fact that some people used standpipes and boreholes which are less likely to be contaminated by soil-transmitted helminths.

Defecating around the water source had a statistically significant association with the prevalence of STH. This aligns with a study done in the Tiko District, South West Region of Cameroon, which revealed that open defecation is a risk factor for STH infections (Tabi *et al*., 2018). This is because open defecation is suitable for parasite distribution which maximizes parasite transmission. After adjusting for the effects of confounders, the study found that use of surface water showed high risk for soil-transmitted helminthiasis infection, though this was not statistically significant. Similarly, (Campbell *et al*., 2016) discovered that there were few consistent associations between STH infections and access to safe water sources. These discrepancies could be attributed to the indirect mode of STH transmission through water.

5.2. Limitations of the study

The research had some limitations; the urine and stool samples were obtained during the rainy season, potentially leading to an underestimation of the occurrence of urinary schistosomiasis and STH, respectively. The study also faced limitations due to the lack of existing data on the overall prevalence of urinary schistosomiasis and STH among women of reproductive age in the study area, leading to the use of prevalence data from a study on school children to calculate the sample size.

5.3. Conclusions

This study provides valuable insights into the epidemiology of urinary schistosomiasis and soil-transmitted helminthiasis among women of reproductive age in Mwaluphamba, Kwale County. The findings highlight the persistent transmission of these infections and identify key risk factors related to WASH practices. These results can inform the development and implementation of more effective, targeted control strategies to reduce the burden of these neglected tropical diseases in the study area and similar endemic settings.

1. This study revealed a moderate prevalence of urinary schistosomiasis (4.7%) and soil-transmitted helminthiasis (4.5%) among women of reproductive age in Mwaluphamba, Kwale County. The prevalence of urinary schistosomiasis was slightly higher than that of STH, indicating that *S. haematobium* infection remains

a significant public health concern in this region. Hookworms were the predominant STH species detected (3.6%), followed by *Trichuris trichiura* (0.9%), while no *Ascaris lumbricoides* infections were observed. These findings underscore the persistent transmission of these parasitic infections in the study area, despite ongoing control efforts.

2. The study did not find statistically significant associations between infection prevalence and most demographic factors such as age, marital status, or occupation. However, education level was significantly associated with urinary schistosomiasis prevalence, with women having no formal education exhibiting the highest prevalence (9.3%) compared to those with primary (4.3%) or secondary (3.5%) education. This finding highlights the potential role of education in reducing infection risk, possibly through improved health literacy and hygiene practices.
3. The study observed that urinary schistosomiasis infections were predominantly of light intensity, with 4.3% of participants showing 1-49 eggs/10 mL of urine and only 0.5% with heavy infections (≥50 eggs/10 mL). Similarly, all STH infections were classified as light intensity according to WHO standards. The median egg count for *S. haematobium* was 18.45 eggs/10 mL, while geometric mean egg counts for *T. trichiura* and hookworms were 56.16 and 48.48 EPG, respectively. Despite the generally low infection intensities, there were significant associations between *S. haematobium* infection and the presence of haematuria, proteinuria, and leukocyturia. These findings suggest that even light intensity infections can have notable clinical implications, emphasizing the importance of screening for these signs to assess potential morbidity.
4. Several key WASH factors were associated with the risk of urinary schistosomiasis. Women without latrine access had a significantly higher risk of infection (aOR 15.70, $p<0.001$). Use of surface water (aOR 1.03, $p=0.010$) and river crossing (aOR 1.13, $p=0.006$) were also significant risk factors, while standpipe water use was protective (aOR 0.02, $p=0.009$). For STH, defecation near water sources was associated with increased risk (OR 4.35, $p=0.008$), although this did not persist in multivariable analysis. These findings emphasize the critical role of improved sanitation and safe water access in reducing schistosomiasis transmission

5.4. Recommendations

To enhance the rate of understanding of urinary schistosomiasis and STH infections and ensure efficient and long-lasting control, this study recommends the following:

1. Strengthen community-based health education programs: The study recommends that comprehensive health education campaigns be intensified, focusing on the risks associated with urinary schistosomiasis and STH. These programs should emphasize the importance of using latrines, practicing good hygiene, and using safe water sources to reduce infection rates.
2. Enhance access to sanitation facilities: To reduce the transmission of urinary schistosomiasis, particularly in high-prevalence areas, there is a need to increase the availability of latrines. The study concluded that women without access to latrines had a significantly higher risk of infection. Therefore, improving access to sanitation facilities, especially in underserved communities, is crucial. Community involvement in the construction and maintenance of these facilities is also recommended to ensure sustainability.
3. Promote the use of safe water sources: The study identified the use of surface water as a significant risk factor for urinary schistosomiasis. It is recommended that efforts be made to develop and maintain safe water infrastructure, such as protected wells and standpipes. Regular monitoring and treatment of water sources should be prioritized to minimize the reliance on unsafe surface water, thereby reducing infection risks.
4. Expand and target Mass Drug Administration (MDA) programs: The study highlighted that women of reproductive age are a vulnerable group often underrepresented in mass deworming campaigns. It is recommended that MDA programs be expanded to include this demographic more comprehensively. Regular deworming can significantly reduce the burden of both urinary schistosomiasis and STH in this population, as indicated by the study’s findings on infection prevalence.
5. Implement regular monitoring and surveillance: Given the study’s conclusion that infection rates vary across different villages and age groups, it is recommended that regular surveillance of schistosomiasis and STH prevalence be conducted. This will allow for timely adjustments to control strategies and ensure they are responsive to emerging patterns of transmission.

5.5. Recommendations for further research

1. Conduct longitudinal studies to monitor transmission dynamics of urinary schistosomiasis and soil-transmitted helminthiasis over time. This will help in understanding the seasonal and environmental factors influencing infection rates and the effectiveness of control measures implemented over extended periods.
2. Assess the efficacy of current treatment and monitor for potential drug resistance among the affected population.
3. Given that the study focused on women of reproductive age, further research should investigate the gender-specific health impacts of these infections. This includes understanding how these diseases affect pregnancy outcomes, maternal health, and the potential intergenerational effects on children.
4. Future studies should consider integrating molecular techniques for more precise identification of parasite species and strains. This can provide deeper insights into the epidemiology of the diseases and help tailor specific interventions to the prevalent strains in the region.

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APPENDIX I: CONSENT FORM

(To be administered in English and Kiswahili)

STUDY TITLE: Epidemiology of urinary schistosomiasis and soil-transmitted helminthiasis among women of reproductive age in Kwale county, Kenya

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Introduction

I am a master student from University of Embu. I was carrying out research in Matuga Sub-County. The aim of this research is to determine the prevalence, intensity and effect of water, hygiene and sanitation on transmission dynamics of *S. haematobium* and STH among women of reproductive age (15-49 years). The importance of this consent form is to give you information that you will use in order to decide whether or not to participate in the study. Feel free to ask questions on whether there are possible risks and benefits and anything else that seems unclear. Your decision to participate in this study is voluntary and that you may withdraw from the study anytime. I request for your cooperation in this study and fully respect your participation.

Aim of the project

The aim of this study is to assess the epidemiology of urinary schistosomiasis and soil-transmitted helminthiasis among women of reproductive age in Kwale county, Kenya.

Benefits

The research will have many benefits both direct and indirect to women of reproductive age, households in the area and other areas prone to *S. haematobium* and STH. Participants benefitted from free urinary schistosomiasis and STH testing. Once tested and found positive, you will be referred to a hospital for care and support where needed. The study will also help in getting information which will aid in inclusion of women of reproductive age in national disease programs. Your assured of no monetary gain if you participate in this study.

Risks, harms and discomforts

There will be no risks or harms on you since you will collect the specimen by your own. In the case where your uncomfortable with some of questionnaire questions, you may decide to skip them. Your also assured that the questionnaire administration was done privately.

What will happen if you agree to participate in study

Once you decide to participate in the study, you will be interviewed by a trained interviewer privately in an area your comfortable when answering questions. You will also be provided with two specimen cups for urine and stool collection. The sample specimen cups will be labelled with a unique identification code for each participant. You will also be asked for your telephone number so as to be contacted when necessary. Upon providing your contact information, it will only be used by those working for the study and that it will never be shared with others. The reason we may contact you is to inform on the status of the test and for follow-up where possible.

Problems and questions

In case of any concern about the study, please call or text the principal investigator: Samuel Mutua, Tel no. **0728366526**. Also, if you have any question regarding your rights as participant contact Kenyatta National Hospital Ethical Research Committee by calling 2726300 Ext. 44102 or email: uonknh_erc@uonbi.ac.ke.

Statement of consent

I have read this consent form or had the information read to me. I have had a chance to questions regarding the study. I also understand that my participation is voluntary and that I am free to withdraw from the study anytime without giving reasons. I freely agree to participate in this research study. I understand that information regarding my personal identity is confidential.

Participant's name (*optional*): ....

Signature .... **Date** ....

Researcher's statement

I .... have fully explained the relevant details of this study to the participant named above and believe that the participant has understood and has willingly and freely given her consent.

Researcher's name ....

Signature .... **Date** ....

APPENDIX II: QUESTIONAIRRE

PART A: SOCIO-DEMOGRAPHIC CHARACTERISTICS

(*Please fill in the blank space & tick one option where suitable*)

1. UNIQUE ID CODE: …………………………………………...
2. DIVISION: ……………………………………………....
3. WARD: ……………………………………………....
4. VILLAGE : …………………………………………......
5. How old are you?
   i. 15-19years [ ]
   ii. 20-29 years [ ]
   iii. 30-39 years [ ]
   iv. 40-49 years [ ]
6. Marital status.
   i. Married [ ]
   ii. Not married [ ]
   iii. Divorced/widowed [ ]
7. How many children do you have? …………………………………
8. What is your highest level of education?
   i. No formal education [ ]
   ii. Primary [ ]
   iii. Secondary/technical [ ]
   iv. Tertiary [ ]
9. How long have you lived in this village? ………………………….
10. What is your main occupation?
    i. Student [ ]
    ii. Farmer [ ]
    iii. Fisher [ ]
    iv. Trader [ ]
    v. Unemployed [ ]
11. Are you aware of Urinary schistosomiasis and Soil-transmitted helminthiasis in the area?
    i. No idea [ ]
    ii. Heard [ ]

iii. Know [ ]

12. When were you lastly treated using Albendazole? ....

i. 3 months ago [ ]

ii. 1 year ago [ ]

iii. Never treated [ ]

13. When were you lastly treated using Praziquantel? ....

i. 3 months ago [ ]

ii. 1year ago [ ]

iii. Never treated [ ]

PART B: <u>WASH QUESTIONNAIRE</u>

14. When do you wash your hands? (*Please tick either yes or No in each row*).

i.	After defecation	Yes ( )	No ( )
ii.	After urination	Yes ( )	No ( )
iii.	Before eating	Yes ( )	No ( )
iv.	When hands are noticeably dirty	Yes ( )	No ( )

15. What do you mostly use to wash your hands? (Tick one option).

i. Water only [ ]
ii. Soap and water [ ]
iii. Ash and water [ ]
iv. Ash only [ ]
v. Other, please specify, ...

16. Do you have a latrine in your home? Yes ( ) No ( )

17. If NO, where do you urinate?

i. Neighbour’s latrine [ ]

ii. Bush [ ]

18. Based on question 17, if NO, where do you defecate?

i. Neighbour’s latrine [ ]

ii. Bush [ ]

19. what is the source of water you use for domestic purposes?

i. Surface water (from rivers, ponds, lakes) [ ]

ii. Borehole, tube well or protected dug well [ ]

iii. Stand pipe (or public tap) [ ]

iv. Rain water collection [ ]

v. Protected spring [ ]

vi. Unprotected dug well [ ]

vii. Piped water into home building [ ]

viii. Other, please specify, ...
.

20. How often do you get into contact with water points for the following reasons? (*Please tick one option for each event in the row*).

	Every day	Few times per week	Once a week	Less than once per week
Swimming for fun				
Crossing rivers to go to a place				
Collecting water for home				
Bathing				
Fishing				
To **wash clothes**				

21. Where do you urinate in case of the above events?

i. In the nearby bush [ ]

ii. Around the water source [ ]

iii. There is a toilet [ ]

Others, specify …………………………………………………………………….

22. Where do you defecate in the case of events mentioned in question 21?

i. In the nearby bush [ ]

ii. Around the water source [ ]

iii. There is a toilet or latrine [ ]

Others, specify………………………………………………………………………...

APPENDIX III: RESEARCH ETHICAL APPROVAL

UNIVERSITY OF NAIROBI
FACULTY 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/432

12th November 2021

Samuel Mutua Ngui
Reg. No.B534/1315/2019
Dept. of Biological Sciences
School of Pure and Applied Sciences
University of Embu

KENYATTA NATIONAL HOSPITAL APPROVED 12 NOV 2021 KNH-UON ERC P.O. BOX 20723 NAIROBI

Dear Samuel

RESEARCH PROPOSAL: EPIDEMIOLOGY OF URINARY SCHISTOSOMIASIS AND SOIL-TRANSMITTED HELMINTHIASIS AMONG WOMEN OF REPRODUCTIVE AGE IN KWALE COUNTY, KENYA (P453/06/2021)

This is to inform you that KNH-UoN ERC has reviewed and approved your above research proposal. Your application approval number is **P453/06/2021**. The approval period is 12th November 2021 – 11th November 2022.

This approval is subject to compliance with the following requirements;

i. Only approved documents including (informed consents, study instruments, MTA) will be used
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by KNH-UoN ERC.
iii. Death and life threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to KNH-UoN ERC 72 hours of notification
iv. Any changes, anticipated or otherwise that may increase the risks or affected 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 relevant institutions.
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 to KNH-UoN ERC.

Protect to discover

APPENDIX IV: COUNTY RESEARCH APPROVAL

COUNTY GOVERNMENT OF KWALE
DEPARTMENT OF HEALTH SERVICES

P.O. Box 4 - 80403
Kwale - KENYA

Email: info@kwale.go.ke
Website: www.kwale.go.ke

REF NO: KWL/6/5/CEC/39/VOL.1/45

DATE: 22ND FEBRUARY, 2022

Samuel Mutua Ngui
Tel: +254728366526
KEMRI/UNIVERISITY OF EMBU

RE: APPROVAL TO CONDUCT RESEARCH IN KWALE COUNTY

Following your application for authorization to carry out the research titled ***"Epidemiology of urinary schistosomiasis and soil-transmitted helminthiasis among women of reproductive age in Kwale County, Kenya"***, approval is hereby granted. This approval is valid until **11th November 2022.** The investigator shall actively engage, and keep informed the Sub/County Health Management Team throughout the study and any changes to the protocol communicated prior to execution.

Yours sincerely,

CEC HEALTH SERVICES
22 FEB 2022
COUNTY
80403, KWALE

Hon. Francis M. Gwama
CECM - Health Services
KWALE COUNTY

CC: Chief Officer Health Services
County Health Director