EFFECTS OF SCHISTOSOMIASIS ON HAEMOGLOBIN CONCENTRATION AND NUTRITIONAL STATUS IN CHILDREN UNDER 5 YEARS, TAITA/TAVETA COUNTY, KENYA.

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DECLARATION

I declare that this work has been composed solely by myself and that it has not been presented in any other institution of higher learning for a degree

Signature:…… Date:……..

PAUL N. NGALUMA

ATTESTATION

We certify that this study is entirely the researcher's own work and submitted for examination with our approval as supervisors.

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DEDICATION

It is with a lot of humility that this work is sincerely dedicated to my beloved late mum Agnes Sofia Ngaluma, my family members for the patience and support they had given me throughout my study.

And to my supervisors and my mentor who accompanied me on this journey. Without them this project would not have been possible.

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LIST OF ABBREVIATIONS & ACRONYMS

CCA	Circulating Cathodic Antigen
ECD	Early Childhood Development
ECP	Eosinophil Cation Protein
EPG	Eggs Per gram
Hb	Hemoglobin
IMCI	Integrated Management of Childhood Illness
KNBS	Kenya National Bureau of Statistics
KU	Kenyatta University
NSBDP	National School Based Programme
PSAC	Pre-school aged children
SCHu	Urinary Schistosomiasis
SCI	Schistosomiasis Control Initiative
SCI	Schistosomiasis Control initiative
SEA	Soluble egg antigen
STH	Soil Transmitted Helminths
WHO	World Health Organization

EXPLANATION OF TERMINOLOGIES

Cerceriae Schistosomiasis larvae which develops inside the snail.

Gynaecopholic Canal Groove where the male worm carries the female worm

Hepatosplenomegaly Enlargement of liver and spleen.

Katayama Fever Manifestation of acute Schistosomiasis characterised by fever, urticarial rash, enlarged spleen and liver

Morbidity The state of being diseased.

Miracidium The larvae which develop inside the egg of schistosome.

Prevalence Number of people having the disease.

Sporocyst Second larval stage of the trematode occurring in snail.

Schistosomulae The cercariae which has shed off its tail and penetrated host.

ABSTRACT

Bilharziasis is a common parasitic disease caused by flatworms called schistosomes. Generally, this infection is common and prevalent disease in Sub-Saharan Africa Middle East, Asia and the Caribbean. With slowed down treatment, the infection in young children (under 5 years) can potentially cause long term harm health effects. This disease causes unsatisfactory development and advancement in this early critical phase of life. This study was meant to attest to the burden of schistosomiasis in Taita Taveta County, by unmasking the prevalence and intensity of the disease among 5 years and below of age. The study recruited children under 5 years from six villages using stratified random technique. The selected children were referred to the nearest health facility for specimen collection. Stool and urine specimens were examined microscopically for helminths. Blood specimens were analyzed for malaria parasites and hemoglobin concentration. Data on anthropometric indices were also collected. Analysis were done using WHO Anthros and IBM SPSS. 132 participants were admitted in the study, predominant sex (53.8%) being males. The age of the participants ranged from 7 to 59 complete months with a median age of 48 (39 – 59) months. The number of participants who tested positive for bilharziasis was 37 (28%; 95% CI 21.1% - 36.2%). Cases of haematobium and mansoni were discovered in 18.9 percent (95% CI 13.2% - 26.5%) and 15.9 percent (95% CI 10.7% - 23.1%) of the sampled participants sequentially. Participants who were positive for other intestinal nematodes 6.8 percent; 95% CI 3.6% - 12.5%. The other STH infections were: ascariasis (6.8%), hookworm infection (4.5%) and trichuriasis (1.5%). The proportion of study participants whohad heavy intensity infections of urinary schistosomiasis were 16.0%. Heavy intensity infections were not detected in STH and *S. mansoni*. Bilharziasis was associated with nutritional aspects which comprises of stunting (odds ratio (OR) 3.665 (95% CI 1.443 - 9.309), p=0.006) and underweight (OR 12.698 (95% CI 3.107 - 51.900, p<0.001). Anemia was evidenced among the participants with schistosome infection when compared with the schistosome-negative participants (57.1 percent versus 42.9 percent respectively, OR 7.897 (95% CI 3.383 – 18.438), p<0.001). This survey confirmed a significant burden of schistosomiasis among population aged 5 years and below in the study area. Additionally, this study indisputable demonstrated that a lot of concerted efforts need to be prioritized for interventions including treatment and deworming to the pre-school age children (PSAC) in the study area. For example, in line with WHO exhortation, since the ova patent prevalence of schistosomiasis in this age group is within the range of more than 10% but not exceeding 50%, then biennial treatment with praziquantel should be conducted. With the great ambitious goal of World health organization of outstretching 75% coverage of prophylactic chemotherapy with a target of major helminthiases among PSAC, the findings from this study emphasizes the need for quick implementation of specific interventions to avoid accelerated morbidity while improving the general health of the population. Our data support the call for institutionalized mass treatment in lieu of school-based approaches only. This will ensure that deserving PSAC are reached by pertinent interventions via alternative delivery platforms such as through the Integrated Management of Childhood Illnesses and through Early Childhood Development and Education Centers. This work equally revealed the connection between flatworm's infections, anemia and nutritional stature in the preferred population.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

Shistosomiasis (Bilharziasis) is a tropical disease affecting over 200 million people predominantly in Asia, Africa and South America more so in areas where water contains numerous fresh water snails which carries the parasite. The disease is caused by blood flukes (Trematode worms) of the genus *Schistosoma* with freshwater snails serving as intermediate hosts. Schistosomiasis affects many people in developing nations particularly children due to their habitual nature of swimming or playing in cercaria infested waters (WHO, 2022).

Schistosomiasis brings closer massive interest in a wide range of scientists, policy makers and various stakeholders due to the impact on subtle and severe morbidity mostly in endemic regions. Recently, attention has been shifting on screening of pre-school children (under 5 years) for schistosomiasis in endemic communities due to the emerging evidence that in high schistosomiasis transmission areas, infants are also infected (Verani *et al*., 2021).

Even with the availability of effective therapy, bilharziasis continue to exert significant morbidity in sub-tropical nations. This has led to under-nutrition, anemia and cognitive impairment, with children harboring the heaviest burden of the disease. The degree of morbidity is related to the amount of eggs output and the number of different species harbored (Kihara *et al*., 2013).

Inability to reach a majority of the children under 5 years in their learning institutions yields to higher rates of schistosomiasis transmission and its negative impacts such as anemia, degenerating cognitive performance and malnutrition. (Kimani *et al*., 2018). This is one of the mainstay challenges faced by the school-based de-worming approach since it leaves out a huge population of those in need of preventive therapy in endemic communities, preschoolers included. This population serves as a reservoir for STH and has been incriminated in sustained reinfections among school age children. The GOK Breaking Transmission Strategy (2019-2023) calls for increased coverage both geographical and therapeutic (extension of treatment to all high risk groups such as the children under 5 years) (GOK, Ministry of Health 2020). Whereas the government has attempted to reach this vulnerable group (children under 5 years) through the National School Based Programme (NSBDP) using avenues such as the Early Childhood Development (ECD) Centres enrolment currently is at about 52%, which implies that a substantial number of these children are at home and hence miss out on the intervention (GOK 2020). These children who are out school are also known to have increased exposure to schistosome infections as they have the latitude to spend more time playing in water bodies that may harbor agents of schistosomiasis (Kimani *et al*., 2018; Mutsaka-Makuvaza *et al*., 2019).

Young children with dual schistosome infections, especially those with heavy worm loads, tend to exhibit more severe unwanted health outcomes and other serious problems, such as liver and bladder complications, than those harboring a single schistosome infection. Such children are also known to perform poorly academically compared with the latter (Kihara *et al.,* 2013; Donohue *et al*., 2019).

A survey conducted in Uganda by Faust *et al*., (2020) demonstrated that administration of praziquantel to children under 5 years was made possible by breaking the tablet into small pieces and sweetened with syrup which made the tablet consumable to the children. In the present study, the point prevalence and indeed the intensity of urinary and intestinal schistosomiasis in children <5years will be determined while the relationship between these parasites, anaemia and nutritional status will be assessed with a view to informing control programmes of the disease in these children.

Research has increasingly shown that various water contact activities such as irrigation among farmers, fish, washing and even swimming as potential risk factors for transmission of schistosomiasis in susceptible communities leaving in schistosomiasis endemic zones (Bala *et al*., 2012; Anto *et al.,* 2013; Damen *et al*., 2018). Further, recent systematic reviews and meta-analysis have demonstrated unequivocally the association between inadequate water and poor sanitation and the burden of schistosomiasis in a community (Grimes *et al.,* 2014; Grimes *et al.,* 2015; Belizario Jr. *et al.,* 2021).

1.2 Problem Statement

In developing nations, children under 5 years and women are the most vulnerable category of people to harbour this infection. Exposure of children under 5 years to cercaria infested waters by their mothers while bathing or through freely playing in *Schistosoma* infested waters should not be ignored. Infants who constitute 30% of any population need to be considered whenever health related issues are to be addressed including de-worming (Odugwo *et al*, 2006). In many schistosomiasis control

programmes, treatment of children under five years has not been considered important (Mwandawiro *et al.*, 2019). It is assumed that this group is not exposed to the infections since they have little access to infested water bodies by their own. However, they are exposure as they are bathed with infested waters and they also play along the banks and shores of the water bodies as their caretakers conduct various water contact activities such as farming, bathing and washing (Nalugwa *et al*., 2015). Also, treatment in this age group is hampered by shortage of clinical and epidemiological data on the disease in this group. This is further aggravated by the lack of an appropriate paediatric praziquantel formulation (Bustinduy *et al.,* 2017). This calls for more studies to be conducted in this population in order to address the aforementioned challenges.

1.3 Justification

In many Schistosomiasis control programmes, treatment of children less than five years has not been considered important as compared to the school going children This may be due to lack of lack of an appropriate paediatric formulation such as a syrup or any sweet tasting formulations of the Praziquantel drug, for instance, a sweet dispersible tablet formulation (Bustinduy *et al.,* 2016). Furthere, there is the aspect of ignorance and/or lack of knowledge of the existence of the infections in this group in endemic areas. Investigation into the extent of the disease in young children (under 5 years) and methods of drug delivery will add more information to the possibility of including these children in the NSBDP. This programme, which has been going on since its inception in 2012, majorly targets children who have enrolled for primary school education (Okoyo *et al*., 2020). It is a core component in the actualization of

the GOK Breaking Transmission Strategy (2019-2023) (GOK, Ministry of Health 2020).

For lack of an alternative in the treatment of schistosomiasis in children under five years, researchers have attempted to come up with solutions to this challenge by proposing administration of, for example, an elixir of honey and powdered *Carica papaya* seeds (Okeneyi *et al*., 2007). A mixture containing a mixture of crushed praziquantel tablets (Kimani *et al*., 2018), and crushed pawpaw seeds mixed with porridge (Matey *et al*., 2020; Songok 2022). Nevertheless, all these products are in the research stage and none has been adopted or recommended by GOK/Ministry of Health.

Studies have increasingly shown that coinfections with *S. mansoni* and *S. haematobium* can occur in humans. For instance, results from a recent study conducted in the south-central part of Côte d'Ivoire confirmed the presence of both *S. mansoni* and *S. haematobium* among adults. Besides, Joof *et al*. (2021) documented the presence of dual schistosome (*S. mansoni* and *Schistosoma haematobium* infection) among primary school children in four selected regions of The Gambia. Similarly, a study by Adel *et al* (2005) in Taveta, Kenya, demonstrated the presence of dual infections in children who were attending school. However, there is no documentation of the same appearing in children under 5 years. This study therefore, aimed to elucidate the possibility of children under 5 years, in the study area, being infected with both or single *Schistosoma* parasites and their nutritional status.

1.4 Research Questions

i. What is the prevalence and intensity of S. *haematobium* and *S. mansoni* in children under 5 years and below in Taita/Taveta County?

ii. What is the nutritional status in children 5 years and below suffering from schistosmiasis in Taita/Taveta CountyTaita Taveta County?

1.5 Objectives

1.5.1 Broad Objective

To investigate the effects of *Schistosomiasis* on hemoglobin concentration and nutritional status in children under 5 years old in Taita/Taveta County.

1.5.2 Specific Objectives

i. To determine the prevalence and intensity of both *Schistosoma haematobium* and *Schistosoma mansoni* in children under 5 years in Taita Taveta County

ii. To investigate the relationship between Schistosomiasis infection and anemia among children under 5 years in Taita Taveta County

iii. To determine the relationship between Schistosomiasis infection and the nutritional status of children under 5 years in Taita Taveta County.

1.5.3 Hypothesis

i. *Schistosoma haematobium* and *Schistosoma mansoni* infections are not prevalent in children under 5 years residing in Taita Taveta County

ii. There is no relationship between schistosomiasis infection and anaemia among children under 5 years residing in Taita Taveta County

iii. There is no relationship between schistosomiasis infection and the nutritional status of children under 5 years in Taita Taveta County.

1.6 Significance of the Study

The Kenyan government is committed to sensitize and fully implement the Schistosomiasis and other Soil Transmitted helminthes control program aimed at scaling down morbidity due to parasitic infections. The results of this study will sensitize health personnel on the need to re-evaluate the treatment strategies of young children who are infected with Schistosomiasis.

The study findings were shared with the Sub-County Medical Officer and the Public Health Office. The feedback on the outcomes of the research were also communicated to the study population in the study area through the local administration leadership.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Schistosomiasis

Schistosomiasis is a major disease of public health concern in humans, occurring in over 74 countries (WHO, 2022)**.** Current estimates place the population of those who are affected by all forms of schistosomiasis, worldwide, at 240 million people. Further, it is estimated that more than 700 million people are at risk of infections with schistosome. Globally, schistosomiasis is estimated to cause about 500,000 deaths annually **(**WHO, 2022). Its current increased prevalence in many areas has numerous causes, including increased irrigation in areas with inadequate sanitation and inadequate water and sanitation as well as areas with poor public health infrastructure (Murungi *et al*., 2021).

Schistosoma haematobium, which causes urogenital schistosomiasis, and *Schistosoma mansoni*, which causes intestinal schistosomiasis, are the two most common schistosome pathogens in Kenya (Liu *et al.*, 2021). The presence of *Bulinus* spp. and *Biomphalaria* spp. as intermediate host snails for *S. haematobium* and *S. mansoni*, respectively, determines the distribution of schistosomiasis in Kenya. Urogenital schistosomiasis is entirely caused by *S. haematobium* and occurs, exclusively, in the coastal region of Kenya (Allan *et al.*, 2020). The persistent high temperatures in this region prevents *Biomphalaria* spp., the host snails for *S. haematobium*, from proliferating. The rest of the area which are endemic for intestinal schistosomiasis are inhabited by host snails of *Bulinus* spp. These areas include central Kenya, Western Kenya and L. Victoria region (Ofulla *et al.*, 2013; Odero *et al.*, 2019). *Bulinus* spp

principally inhabit small inland freshwater water bodies such as seasonal pools, drainage canals, quarry pits, and streams (Opisa *et al.*, 2011).

Especially in rural regions, schistosomiasis infection continues to be a significant socioeconomic burden for low-income earners. Anemia, persistent pain, diarrhea, and malnutrition are among symptoms of schistosomiasis, which can lead to poor academic performance and fitness. Generate significant physical and socioeconomic losses, with the majority of these losses manifesting as a diminished ability to work as a result of both physical crippling and adverse mental health impacts (Masong *et al.*, 2021). Furthermore, health-related out-of-pocket expenses as a result of misdiagnosis or a lack of access to quick diagnosis might exacerbate misery. Despite the fact that the condition is not deadly, affected individuals and their families may face significant medical costs and become less economically productive (Turner *et al*., 2020).

Research has indicated that the current approach of controlling helminthiasis, schistosomiasis included, through school based deworming may be inadequate for breaking the transmission of these infections. In particular, the school-based MDA could, potentially, be missing key reservoirs of infection such as adults (Njenga *et al*., 2011) and the preschool-aged children (Pickering *et al.*, 2019). Further, according to Odogwu *et al.* (2006), Schistosomiasis in infants has been of great concern. This is because the infected child under 5 years contributes to an important role in maintaining a local disease transmission. Although their infection rate is less severe than that of school-aged children, many such under 5-year-olds have a continuous habit, often multiple, routine contacts with water, and many have their soiled

garments washed in pools of water, increasing the amount of *S. mansoni* eggs reaching fresh water snails. Although, in Africa, congenital schistosomiasis transmission is uncommon (Othman *et al*., 2010).

Infant infections are quite rampant upon the specific notably water related behaviors of their parents or aging siblings who often look after under 5 years of age children in areas where the disease is quiet endemic (Odogwu *et al*., 2006). Such research findings emphasize the need for additional control strategies to supplement school-based deworming if the goal of interrupting environmental transmission of these parasites is going to be attained.

Research and control strategies directed at preschool-aged children (children under 5 years), have lagged behind those in older children and adults. There is a dire shortage of studies mapping the level of infection and morbidity in this group though infection and disease quantification is critical to inform planning and deployment of targeted public health interventions aimed at this group (Osakunor *et al.,* 2018). Indeed, several authors have reported the prevalence of schistosomiasis in infants though, often, no detailed follow-ups of the children and their mothers including growth and nutritional status has been done. As a result, there is lack of specific information on what the schistosome infections mean in terms of the child's overall current and future health (Osakunor *et al.,* 2018). However, with the recent WHO revision of the schistosomiasis treatment guidelines to include PSAC, and the recognition of gaps in our current knowledge on the disease and its treatment in this age group, and there is now a concerted effort to address these shortcomings.

2.1.1 Prevalence

In the African continent, *S. haematobium* and *S. mansoni* prevalence and intensity increases with age especially between 5-20 years. With increasing age, the rate of decrease accelerates (Bustinduy *et al*., 2017). Despite the fact that the estimations show a substantial number of people affected, the disease often receives less attention from health care providers, national governments, and international organizations than it deserves. This is partly due to the fact that some infections are asymptomatic at first. (Aagaard-Hansen *et al*., 2008).

In Africa, schistisomiasis is caused predominantly by infection with *S. haematobium* and *S. mansoni* while prevalence and intensity increases with age especially between 5-20 years and declines more rapidly with advance in age. There has been a massive improvement in financial and technical support for Schistosomes and helminths studies. National de-worming programmes have been overwhelmingly launched and internationally supported within the East African region. National de-worming programmes have been initiated in these countries with great support from the bilharziasis control initiative programme and the global partnership for neglected tropical disorders (Kihara *et al*., 2009).

The presence of schistosome antigens in urine after Praziquatel therapy may provide both re-infection resistance and the ability to elicit a distinct response to blood flukes and schistosomal egg antigens after another infection. Children as young as 5 months old in Uganda were positive for *S. mansoni*, despite the fact that their mothers tested negative for the infection. This demonstrated that, perhaps, the newborns had pre-patent infections (Colley *et al*., 2014).

In Egypt, there were some comparisons due to changes in urinary schistosomiasis egg counts over 36 months' length of time in 2 rural habitations. In the initial scenario, disease propagation was interrupted due to chemical control of snails, secondly; control of schistosomiasis transmission was not tried. Changes with time due to egg counts in the first rural habitat gave room for the calculation of fluke's life span, and hence of the amount of new infection, by age group brackets, that was taking place in the second rural habitat. According to Chapman *et al*., (2018), it was summarized that adult's possessed a minimum of 1000 times less new infections than school going children.

In Brazil, a comparison of infected cases and uninfected controls showed that infection was broadly associated with movements of people from rural to urban areas and low income earners. But epidemiology study of *S. mansoni* which was under taken in sub urban area of huge and populated industrialized city of Brazil (Belo Horizonte) demonstrated the existence of *S. mansoni* transmission in urban area and occurrence of transmission at 20% prevalence. However, water contact pattern remain to be predictive of infections with schistosome in the endemic areas (Oladejo *et al*., 2019; Oso *et al*., 2020).

The possible existence of urinary and intestinal schistosomiasis tolerance to praziquantel therapy had been reported in Senegal, where the cure rate, 12 weeks after proper therapy, was 18% (Bergquist *et al*., 2018). However, in Egypt the use of Praziquantel is rampant, there are emerging reports of *S. mansoni* and *S. haematobium* resistance to treatment (Inobaya *et al*., 2014).This has propagated the search for

possible vaccines, alternative cure and other possible control approaches (Chen *et al*., 2012; Malhotra *et al*., 2015).

The World health organisation recommends massive de-worming with Praziquantel as the drug of choice for schistosome infections and albendazole for other intestinal nematodes if the prevalence of infections in any area is exceeding ten percent and possesses the target of de-worming seventy-five percent of school going pupils and other susceptible individuals in endemic habitations. This objective led many nations to initiate nationwide school based de-worming programmes for controlling schistosomiasis and soil transmitted helminthes (STH) (Brooker *et al.,* 2009).

According to Sturrock *et al.,* (2011*)* control programmes based on oral drug delivery mostly Praziquantel to control morbidity and avoiding either contaminating of possible aquatic snail's habitat by human faeces containing the ova from reaching the waters or human exposure to cercarial infested waters markedly reduces the chances of transmission. The UN published design on how to build water irrigation schemes and dams that should be adhered to so that it prevents the snails from breeding and cutting down the possibility of human contact. (WHO, 2000). Overall, WHO recommended the incorporation of the technical considerations into dam planning, construction, operation, rehabilitation and disaster preparedness including budgeting socially acceptable measures to safeguard, mitigate and promote human health (WHO, 2000). However, mass education towards rural population to discourage human water contact and exposure to transmission has little room of success without the availability of safe water supply sources, recreational facilities for the school going children and acceptable means of proper excreta disposal (Oso *et al*., 2020).).

It has been observed that the most achievable control programmes include those that comprises primary methods of reducing transmission including snails population control using molluscides even at a reduced level (Allan *et al*., 2020). Meanwhile, Sturrock *et al*., (2011), pointed out that any delays in transmission control, slows down re-infection and lengthen the period between therapy administrations and thus reducing drug delivery.

In Kenya, there has been concerted efforts from the central government and international funding agencies with the specific goal being to deliver de-worming programmes through the school system. This is because the school system is where the target population is dominant and has yielded good control of Schistosomiasis and pleasing educational outcomes (Karanja *et al*., 2009).

Kenyan coastline is often known predominantly to harbour urinary schistosomiasis and to determine school going children with urinary schistosomiasis, well-structured questionnaires were administered by the student's teachers which again reiterated high infection incidences in quiet a number of settings (Brooker *et al*., 2009). A study done in eastern part of Kenya in an area next to the Thange river in Makueni County showed that within 12 months of people settling down, there was a high level of infection rate among the adults peaking at 30 years but later on children showed a significantly higher intensity after 3 years (WHO, 1994).

In Kenya, schistosomiasis is common in Kirinyaga County more specific in Mwea irrigation scheme, Ukambani areas and Taita/Taveta County. High constant temperatures among other limiting factors in Taita/Taveta County may account for the

failure of *Biomphalaria* spp which transmits intestinal schistosomiasis to establish in this area. However, the *S. haematobium* intermediate hosts of the *Bulinus* spp are more tolerant to high temperatures and therefore thrives so well in this area (WHO, 2000).

The Kenyan National School Based Deworming program (NSBDP) was launched in 2012 with the aim of reducing the burden of the disease among children. The program provides annual MDA to 66 endemic sub-counties spread out across four endemic regions; Western, Nyanza, Rift Valley, and Coast and three regions with minimal risk; Central, Eastern and North Eastern. The NSBDP which forms a key component of the country's national response strategy to control STH and schistosome infections, as a public health problem, functions by administering treatment to all children including those out of school. The program has so far offered consistent and high MDA coverage for the last 6 years, with some variation at the county level (Mwandawiro *et al*., 2019). *S. mansoni* prevalence was 2.2% (95% CI: 1.2–4.3) and *S. haematobium* prevalence was 0.3% (95% CI: 0.1–1.0). A recent evaluation of the NSBDP revealed that *S. haematobium* infections prevalence had reduced significantly when compared with the baseline prevalence, while *S. mansoni* infections showed no significant prevalence reductions over the period under considerations. (Okoyo *et al.,* 2020).

A study by Mwandawiro *et al.,* (2019) evaluated the presence of *Schistosoma haematobium* infections among school children in four counties in the coastal region of Kenya following five years of conducting annual mass treatments in the region. Kwale and Kilifi counties most prevalent for *S. haematobium* at 5.3% and 1.5%,

respectively. The other two counties (Mombasa and Taita Taveta) maintained nil *S. haematobium* infection level over the five-year period that was under assessment. The research also showed that the reductions in schistosome infections varied by county. Over the five-year period, ten counties showed an increase in *S. mansoni* prevalence rather than a relative reduction, with no county considerably reducing S. mansoni frequency by even 50%. Most *S. mansoni* infections were found in three counties (Busia (8.0 percent), Kisumu (5.4 percent), and Homabay (3.7 percent)] at the end of the survey, while the remainder of the counties had a prevalence of less than 1%, with the exception of Narok County (1.3 percent).

Pre-treatment prevalence levels of *S. mansoni* in East Uyoma schools in Nyanza region ranged from 5% to 43.2% with an average prevalence of 17.8%. Mean intensity (± SD) of eggs per gram (EPG) was 166.8 ± 295.1 (range 12–1560; CI: 99.8 - 222.0). At the six-month follow-up, 576 children were surveyed. *S. mansoni* infections were detected in 38 out of 84 new children who had recently joined the schools and had not participated in the baseline survey. This migration was mostly caused by the post-election violence and led to higher post-treatment prevalence levels in two schools (Mwinzi *et al*., 2012).

A cross-sectional survey of 368 primary school children conducted in Kwale identified factors associated with the intensity of *Schistosoma haematobium* and hookworm infections. The negative binomial generalized linear mixed model showed the intensity of *S. haematobium* infection was much higher among Muslims and school children from low socioeconomic status households. High intensity of

hookworm infection was associated with sex, distance to river and history of anthelmintic treatment (Chadeka *et al*., 2017).

A study conducted in Rachuonyo, Homabay County revealed that among the 474 school going children, 2.3% of the sampled population harbored both *S. mansoni* and *S.haematobium* infections. This was the first time mixed infection was being reported in that region after Taveta and some parts of lower eastern in Kenya (Kihara *et al*., 2013).

2.1.2 Effects of Schistosomiasis

The terminal – spined eggs of *S. haematobium* may erode blood vessel and cause hemorrhages. The eggs deposited in the tissues act like foreign protein and have an irritative effect leading to round cell infiltration and connective tissue hyperplasia. The tissue reaction in these cases produces what is known as formation of a *pseudo tubercle* around each egg. The early nodules are highly cellular and are composed of eosinophils, giant cells, monocytes and lymphocytes which later on the cellular reaction tends to disappear and is replaced by a whorl of fibrous tissue and calcified eggs may be found. Large and progressive granulomas are found only around the eggs and may cause a diffuse fibrosis (Satoskar, 2009).

Clinical manifestations of schistosomiasis include acute fever (Katayama syndrome) and chronic manifestations. Katayama syndrome may include symptoms such as fever and respiratory symptoms. In *Schistosoma haematobium* chronic infections can cause bladder cancer. In *Schistosoma japonicum* and *Schistosoma mansoni*, chronic inflammation can cause clinical manifestations such as ulceration and fibrosis.

Clinical manifestations include Kayama syndrome and chronic diseases. Chronic manifestations can also lead to bladder cancer in *S. haematobium* while in *S. japonicum* and *S. mansoni*, they can lead to bowel wall ulceration and hyperplasia (Nelwan, 2020).

Intestinal schistosomiasis occurs due to chronic egg-mediated swelling of the bowel wall. The patients may present with fatigue, severe abdominal pain, diarrhoea and sometimes dysentery-like illness with bloody bowel movements. A lot of eggs in the gut wall induces inflammation, hyperplasia, massive ulceration and micro abscess formation while occult blood in the stool specimen is common (Satoskar, 2009).

Effect of schistosomiasis on Haemoglobin status of children

In spite of its toxicity, haem is a critical factor for numerous biological reactions, and is an important iron source for these helminths. Schistosomes ingest host erythrocytes, releasing enormous quantities of haem. (Toh *et al.*, 2015). Specifically, the schistosomes on reaching adulthood reside in the blood vessels of their human hosts, where they ingest large amounts of erythrocytes as a key component of their nutritional requirements (Whitfield 1979). The schistosomes use the globin portion of haemoglobin from the erythrocytes for their amino acid requirements (Zussman *et al*., 1970). Haem is an iron containing tetra pyrrole. It serves as a co-factor for many biologically important haemoproteins, such as cytochrome oxidase and haemoglobin. The reactive nature of haem makes it a potentially toxic compound. As a result, throughout haemoglobin catabolism, most of the compound is quickly detoxified and subsequently eliminated by egestion from the body of schistosomes (Oliveira *et al*., 2000). Further, schistosomes tend to reclaim exogenous haem to supplement their

porphyrin requirements. Similarly, exogenous haem is also used by schistosome parasites as an iron source (Glanfield *et al*., 2007). Additionally, somal ferritin which is the dominant iron storage protein in schistosome parasites is up-regulated in schistosomula which is exclusively cultured in the presence of the red blood cells (Gobert *et al*., 2010).

Literature review on the association between schistosomiasis and anaemia indicate disparities in research findings. A study conducted in Tanzania by Mnkugwe *et al*., (2020) demonstrated that children who were infected with intestinal schistosomiasis had slightly lower median haemoglobin concentration compared with their counterparts who were not infected (12.5versus 12.8 g/dL, respectively). However, this association between haemoglobin status and schistosome infection was not statistically significant (p = 0.360). A study on *Schistosomas mansoni* in Kenya conducted by Sturrock et al (2011) investigated the relationship between *S. mansoni* infection and anaemia in school children at the community level. The study reported that *S. mansoni* caused severe anaemia at the community level and the haemoglobin levels dropped as the intensity of the infections increased. . There was no significant relationship found between intestinal schistosomiasis infection and anaemia in a study done among children in Nothern Angola by Sousa-Figueiredo *et al*., (2012) as well as in a research conducted among primary schoolchildren in two onshore villages in Rorya District, North-Western in Tanzania by Munisi *et al*., (2016).

Effect of schistosomiasis on the Nutrition status of children

Schistosome infections are known to be associated with impairment of growth in children, poor nutritional status and impaired cognitive ability especially in children

(Colley *et al.,* 2014). A recent study on intestinal schistosomiasis among school children in Sana'a Governorate, Yemen reported that the prevalence of stunting among school children was 45.8% with 26.3% of the children being severely stunted. The prevalence of wasting was 25% with 9.7% of the children being severely wasted. In this study, stunting was significantly associated with *S. mansoni* infection in children (OR = 4.0, 95%CI: 2.00, 8.01, P = 0.002) (Al-Haidari et al 2021). In a study done in Nigeria which involved a total of 462 children, analysis of the height for age Z-scores indicated that 29 children (22.7%) with light infection and 60 children (48.4%) with heavy schistosome infections were severely malnourished ($p<0.05$). The correlation between schistosome infection and malnutrition was statistically significant with higher the intensity of schistosome infections being positive correlated with malnutrition in the study children ($p<0.05$). On the contrary, in these Nigerian study, nutritional status of the children based on the weight for age Z-scores was not significantly related ($p>0.05$) (Hassan et al 2011). Mnkugwe *et al*., (2020) researched on the prevalence of undernutrition (stunting and wasting) and its relationship with schistosomiasis among children. The study revealed that 29.0% of children were stunted while 11.3% of the children were reported to be wasted. Further analysis of the study data showed that the association between stunting and intestinal schistosomiasis infection was not statistically significant ($p = 0.530$). The relationship between intestinal schistosomiasis infection and wasting was also not statistically significant ($p = 0.410$). Negative binomial regression analysis, on the other hand, indicated that stunting was a significant predictor of high eggs count/gram of stool ($p<0.001$). A recent study conducted in Mbita, Homa Bay County, Western Kenya confirmed the existence of *S. mansoni* infection in young pre-school children. In this study no evidence of statistically significant association was recorded on assessment

of the relationship between *S. mansoni* infection and health status of the participating children as assessed by their nutritional status ($p>0.05$) (Sassa *et al*., 2022).

2.2 Laboratory Diagnosis

2.2.1 *Schistosoma haematobium*

This is based on the demonstration of eggs of *S. haematobium* in a microscopical examination of urine deposit. Nowadays a sophisticated filtration technique gives a quantitative estimation of egg excretion. A piece of vesicle mucosa is removed by cystoscopic biopsy. The excised tissue is divided into two pieces. One piece is compressed between two slides and checked for eggs under the low power of the microscope while the other piece is placed in a fixative for histological examination (Satoskar, 2009).

Presence of more reliable, rapid and less expensive modern techniques such as ELISA that can replace parasitological examination of urine would greatly increase the capacity to diagnose most of the parasitic infections. Measurement of various fluke's specific antigens is on the increase to quantify both infection and morbidity (Kihara *et al*., 2009).

2.2.2 *Schistosoma mansoni*

Detection of *S. mansoni* eggs in a standardized fecal smear preparation (Kato-Katz technique as described by Katz *et al* (1972) is the most preferred method. The extent of egg production fluctuates over time, and as many as three separate stool specimens may be required for microscopic examination. The use of formal-ether technique for sedimentation and concentration may increase the diagnostic yield. Egg viability

testing may help to assess the presence or absence of active infection, particularly after drug therapy.

Briefly, formal-ether technique involves mixing of feces with normal saline in a glass container. In a funnel, two layers of gauze are used to strain the contents into a centrifuge tube. A total of 2.5 mL of 10% formaldehyde and 1 mL of ether are added. The solution is thoroughly mixed before centrifugation at 1000 revolutions per minute for 3 minutes. The supernatant is then collected, and the sediment is used to make the slides. Two slides (one for saline and the other for iodine) are made, then covered with a cover slide and viewed under a microscope (Yimer *et al.*, 2015).

2.3 Prevention and Control

Prevention of schistosomiasis infection involves avoidance of spending much time or wading in freshwater where schistosomiasis is endemic. Oceanic and chlorinated swimming pools are usually safe to swim. Water from canals and other sources may be contaminated with cercaria; water meant for bathing should be boiled for 1 minute to kill the infective stage of the flukes, cooled down to avoid scalding before showering. Good control measures involve mass drug administration in the exposed community and targeted treatment of school-age children. Challenges emerging with prevention and control of schistosomiasis includes; Chemicals used to kill the specific snails are harmful to other aquatic life and, if proper treatment strategy is not sustained, the breeding of snails will be uncontrollable (WHO, 2016).

2.4 Treatment

The drugs having specific actions on the Schistosomes are Praziquantel (40mg/kg/day in two doses for 1 day) and Metrifonate (single dose of 7.5mg to 10mg/kg body weight, weekly for 3 weeks) (Nelwan, 2020). Protocols for treatment of schistosomiasis were developed by the world health organization in the community level based on the magnitude the disease has impacted on the children in the villages. In villages with more than 50% of children presenting with hematuria, all the children in that village should receive treatment (Aruleba *et al*., 2019). While those villages with only 20 % of the children have blood in urine, only the children attending school are initiated to treatment. However in cases where less than 20% of children have symptoms, mass drug therapy is rarely initiated. The effectiveness of the drug PZQ has shown to be eight times more than that of Metrifonate (WHO, 2016; King *et al*., 2020).

A study done along the Kenyan coast showed that after treatment with Praziquantel, there was a decline in mean egg output in day two and then a sharp increase on days four to five. Thereafter, there was a drastica reduction for both sexes (males and females) over the next 14 days. It was noted that there was an increase in urine soluble egg antigen (SEA) in male children on day 24 which dropped on day 26 and remained quite stable at that level (Kihara *et al*., 2009).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

The survey was administered at Taveta, Sub-county within Taita/Taveta County. Its location is approximately 200 Km northwest of Mombasa County and borders Kajiado County to the North-west, and Tanzania to the South and South-west. The County covers an estimated area of 17,084.1 Km2 and lies between latitudes 2° 46` South and 4° 10`South and longitudes 37° 36` East and 30° 14` East. As of 2019 national census, the estimated population of the county was 340, 664 inhabitants with the population of females and males being 173,337 and 167,327 respectively. The population of children under five years was estimated to be 38,689(19,389 males and 19,300 females) in 2019 (Kenya National Bureau of Statistics (KNBS), 2019).

3.2 Study Design

A cross-sectional study design was adopted in conducting the current study.

3.3 Study Population

Children under 5 years in Taita Taveta County were enrolled in the study. The target population comprised 17,384 children based on the statistics of the 2019 Kenya Population and Housing Census (KNBS 2019).

3.3.1 Inclusion Criteria

Included being a resident of the study area for a period not less than 12 months and the caregiver or the parent providing consent for the child to take part in the research.

The participants should have been not been involved in any Schistosomiasis control activities for the last one year.

3.3.2 Exclusion Criteria

All children 5 years and below who were not residing of the study area for a period of 12 months, whose parents did not give consent and were involved in schistosomiasis control activities for the last one year while those suffering from malaria parasitemia and other intestinal nematodes did not form part of the study sample. Also, children who were critically ill were equally not included in the study.

3.4 Determination of Sample Size

A sample of 132 children was recruited (According to Fisher's *et al*., 1998).

Using the formula:

$$N = \frac{Z^2 . p.q}{e^2}$$

n= desired Sample size

P value= the percentage of defective in the world.

q=1-p

z=1.96 (According to the table of area under normal curve for a confidence level of 95%).

$e^{2 =}$ 0.05 (Estimate should fall within 5% of true value).

n=sample size = 95% C.I=1-0.95=0.05, check table 3= 1.96, which is equivalent to Z.

P=current Schistosomiasis prevalence in the area (9.5%) (Kihara *et al*, 2009).

Q=90.5 (100-9.5)

i.e. = $N = \frac{(1.96)^2 \, x \, 0.095 \, x \, 0.905}{(0.05)^2}$ = 132.

3.5 Sampling Technique

A stratified random sampling technique was adopted in this study. All 6 randomly-selected villages, namely; Njoro, Mshegheshenі, Kiwalwa, Kitobo, Miereni, and Mwarusa, from Bomani ward, were registered, their size determined with the exact number of households, which constituted the sampling frame. Young children aged 5 years and below fitting into the inclusion criteria were registered and enrolled in the study. The number of children selected for participation in the study per village were allocated using the probability proportionate to sample size approach. The distribution of the sampled children by the study villages is shown in Table 3.1.

Table 3.1: The distribution of the sample size by the study villages

S. No.	Village	Household population (N)	Sample size (n)
1	Njoro	116	23
2	Mshegheshenі	56	11
3	Kiwalwa	72	14
4	Kitobo	207	41
5	Miereni	112	22
6	Mwarusa	99	20
	Total	**662**	**132**

All eligible children per village were listed, assigned a sequential number, their numbers were put in a bucket and then randomly selected and this constituted to the required sample size of 132 for the entire study. The mothers with the selected children visited the nearest health facility for sample collection on different days for a period of 4 days.

3.6 Specimen Collection

3.6.1 Urine and Stool Specimens

Urine and stool specimen collection containers were labelled with unique identifiers and specimen bags were issued to the participating children's mothers to collect specimens as directed by the study nurses. The specimens were collected randomly between 10:00hrs and 14:00hrs while the parents were advised not to introduce some contaminants to the specimens by not touching the inside of the containers or the lid. The containers were capped tight after collection of specimens to avoid exposures and contamination due to leakages.

3.6.2 Blood Specimen

The frosted end of the cleaned slides were labelled with participant's number as the unique identifier, date and time of collection. The preferred finger was selected for puncture, cleaned with 70 percent ethanol. A pricking of the finger was done and the first drop of blood was wiped off using clean gauze. Squeezing of the finger was done gently and a drop was used to estimate the haemoglobin concentration as explained in 3.8.3 while two drops were collected on the slide for both thick and thin blood films. Malaria parasite antigen testing was done on site using SD Bioline Malaria Ag P.f/Pan (Standard Diagnostics Inc., Korea) rapid test kits as outlined in the manufacturers' inserts.

For a thin smear, a spreader was held at an angle of 45°, toward the drop of blood on the glass slide, blood was allowed to spread along the entire length of the spreader slide. At the same angle, the spreader was pushed forward rapidly and smoothly. Thick films were prepared in a circular manner, the size of a dime (diameter 1-2 cm).

Both the thin and thick films were allowed to completely air dry before packaging and transportation.

3.7 Shipment of Specimens

All specimens were shipped to the Sub-county hospital laboratory for analysis by a trained motorist. The collection and/or transport container for both urine and stool specimens had a secured lid which was leak-resistant while the slides were arranged in a slide carrier to avoid breakages.

3.8 Laboratory Procedures

3.8.1 Urine Membrane Filtration Technique

Collection of freshly voided urine was done between 10:00 AM and 2:00 PM and processed using the filtration technique. Briefly, urine samples were agitated to guarantee adequate dispersal of eggs. 10mls of urine was drawn using a syringe and passed through nucleopore-H filters. Thereafter the filters were mounted on a microscope slide. Microscopic examinations were performed and the presence and number of *S. haematobium eggs* noted and counted.

3.8.2 Kato Katz Technique

This technique quantifies the *Schistosoma mansoni* eggs in faecal specimen. The sample unique number was written on the clean glass slide and a technique plastic template was placed on the slide. A considerably little amount of the faecal specimen was placed on top of a paper towel while a piece of nylon screen pressed on it. Wooden spatula was used to gently scoop filtered fine faecal sample through the screen so that only the faecal matter remained. The fine filtered faeces was scooped

up to fill the hole in the template, while excess fine faeces were avoided by levelling the faeces off. Template was lifted off, washed and disinfected for re-use.

Cellophane papers immersed overnight in glycerol solution and methylene blue were placed over the sample. Slide was placed and pressed over the sample and downwards which had to move the sample in a circle. The resultant smears were examined microscopically. Presence and number of species of parasitic eggs observed were recorded.

3.8.3 Haemoglobin Estimation

Hemoglobin estimation was measured from the point of sample collection and read in portable battery powered equipment (haemocue, Anglom Sweden). Anemia was clearly identified as hemoglobin concentration <11 g/dl (Zetterstrom, 2004).

3.8.4 Nutritional Status

Weight, height and MUAC measurements of all children under 5 years were taken during visits to the health facilities using a seca scale balance and a 4-colour MUAC tape respectively. Using the 4-colour tape measurements, a child was classified as properly nourished, risk of malnutrition, moderately malnourished or severely malnourished if the measurement fall within the green, yellow, orange and red zones respectively.

While appropriate anthropometric indices including the weight for age z scores (WAZ), weight for height z scores (WHZ) and height for age z scores (HAZ) were computed based on using WHO guidelines on child growth standards (Appendix X).

All anthropometric measurements were conducted with calibrated and validated instruments.

3.9 Management of Data and Statistical Analysis

Intensities of STH and the trematodes infections were stratified in relation to the cut-offs as stipulated in the world health organization guidelines. Anemia was interpreted as hemoglobin<11 g/dl. Appropriate anthropometric indices including weight-for-age z-scores, weight for height z-scores and height for age z-scores were computed in relation to WHO child growth standards.

Analysis of nutritional data was performed using WHO Anthro 3.2.2 while other statistical analyses were done using IBM SPSS Statistics 22.0 (IBM, Chicago, IL, USA). Normally distributed continuous data were described using mean ± standard deviation (SD). Continuous data which was not normally distributed was described using median and interquartile range (IQR).Variables were described using absolute numbers and corresponding proportions. Chi-square ($\chi 2$) test, or Fisher's exact test where appropriate, were used to check the associations of both the independent and the dependent variables. The odds ratio were calculated based on the following formula:

$$\text{Odds ratio} = \frac{PG_1 / (1 - PG_1)}{PG_2 / (1 - PG_2)}$$

Where "PG1" represents the odds of the event of interest for Group 1, and "PG2" represents the odds of the event of interest for Group 2.

A p-value of less than 0.05 was set as the threshold of statistical significance in all hypotheses tests.

3.10 Ethical Consideration

Relevant scientific and ethical reviews and approvals were provided by the Kenyatta University Ethical Review Committee (Appendix III). Written informed consents were acquired from the mothers whose children participated in the study. Permission for this study was granted by the MoH, Taita/Taveta County (Appendix VI). All children who were found positive for infections with schistosomes and/or STH were treated in a local public health facility according to MoH guidelines.

Information on diagnosis of the child was treated confidentially and was only disclosed to authorized person's i.e. Medical personnel in the health centers. All laboratory diagnosis and treatment for parasitic infection was done without any payments incurred by the parents. Collection of urine specimens did not involve invasive procedures. Capillary blood samples were collected for malaria screening and the minimal pain inflicted during the capillary puncture did not last for a long period of time.

CHAPTER FOUR

4.0 RESULTS

4.1 Study Participants Demographics

The characteristics of the 132 children (<5 years) who took part in the current survey showed that the age of the enrolled participants ranged from 7 to 59 months. Majority of the surveyed children were male (53.8%). The median (IQR) age was 48 (39-59) months. Those who were aged between 24 and 48 months were the majority (63.8%) while those aged less than 24 months comprised 9.8% of the study participants. The rest (26.5%) were aged more than 48 months (Table 4.1)

Table 4.1: Attributes of the survey participants

Characteristic	**Number (n=132)**	**%**
Age		
< 3 years	104	9.8
3- <5 years	28	63.6
Sex		
Male	71	53.8
Female	61	46.2

4.2 Prevalence and Severity of the Intestinal Parasitic Infections of the Enrolled Participants under 5 years in Taita Taveta County

The proportion of study participants who were positive for schistosomiasis was 28 % (95% CI 21.1%-36.2%). The prevalence of *S. haematobium* and *S. mansoni* were 18.9% (95% CI 13.2%-26.5%) and 15.9% (95% CI 10.7%-23.1%) respectively. Infection with either of the two species of schistosomes was reported in 21.2% of the children. Nine children had co-infections with both species of schistosomes (6.8%). A total of seventeen participants were infected with any of the intestinal nematode species (Prevalence of 12.9% (95% CI 8.2%-19.7%); Further, the prevalence of

infections with STH species were as follows: *A. lumbricoides* 6.8% (95% CI 3.6%-12.5%), hookworm 4.5% (95% CI 2.1%-9.6%), and *T. trichiura* 1.5% (95% CI 0.4%-5.4%) (Table 4.3). These distribution of the infections with helminths among pre-school age children is illustrated in Figure 4.1.

Table 4.2: Prevalence of intestinal parasitic infections of the enrolled participants under 5 years in Taita Taveta County

Parasite	**Number (n=132)**	**Prevalence (%)**
Schistosomiasis positive		
Yes	37	28.0
No	95	72.0
S. haematobium		
Positive	25	18.9
Negative	107	81.1
S. mansoni		
Positive	21	15.9
Negative	111	84.1
Schistosomiasis		
No infection	95	72.0
Single infection	28	21.2
Dual infection	9	6.8
STH		
Positive	17	12.9
Negative	115	87.1
A. lumbricoides		
Positive	9	6.8
Negative	119	93.2
Hookworm		
Positive	6	4.5
Negative	127	95.5
T. trichiura		
Positive	2	1.5
Negative	126	98.5
Malaria		
Positive	3	2.3
Negative	129	97.7

The prevalence of malaria was 2.3% (95% CI 0.8% - 6.5%).

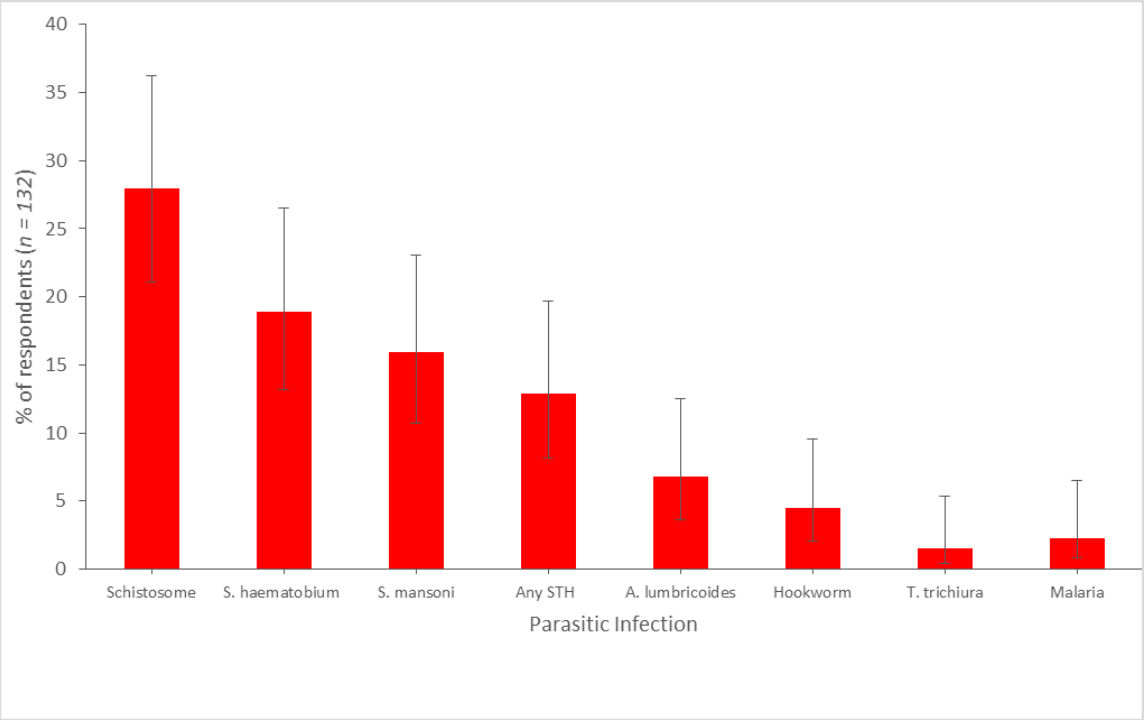

Figure 4.1: Prevalence of parasitic infections. The error bars indicate 95% confidence intervals

4.3 Nutritional Status of the Enrolled Children under 5 years in Taita/Taveta County

Stunting and wasting was observed in 17.4% and 15.2% of the sampled children respectively. Children who were underweight comprised 8.3% of the study participants. The mean ±standard deviation (SD) hemoglobin concentration was 11.6±1.25 g/dl (range: 8.7 to 16.7 g/dl). The hemoglobin concentration did not differ significantly by sex (11.6 ± 0.14 g/dl boys and 11.6 ± 0.16 g/dl for girls, p=0.922). The overall prevalence of anemia was 31.8% (95% CI 24.5% - 40.2%). Those whose mean upper arm circumference and body mass index for-age z-scores were classified as low (<-2) were 7.6% and 29.5% respectively (Table 4.2).

Table 4.3: Nutritional status of the enrolled children

Status	Category	Count (n=132)	%
Weight for length/height z-scores <-2	Wasting (< 2 z-scores)	20	15.2
	Normal (≥ -2 z-scores)	112	84.8
Length/height for age z-scores< -2	Stunting (< 2 z-scores)	23	17.4
	Normal (≥ -2 z-scores)	109	82.6
Weight for age z-scores <-2	Underweight (< -2 z-scores)	11	8.3
	Normal (≥ 2 z-scores)	121	91.7
BMI for age Z scores <-2	Low (< -2 z-scores)	39	29.5
	Normal (≥ 2 z-scores)	93	70.5
MUAC Z scores <-2	Low (< -2 z-scores)	10	7.6
	Normal (≥ -2 z-scores)	122	92.4
Haemoglobin levels	Anemic (<11 g/dl)	42	31.8
	Normal (≥ 11 g/dl)	90	68.2
Haemoglobin levels (mean±se)	Boys	11.6 ± 0.14 g/dl	
	Girls	11.6 ± 0.16 g/dl	

4.3.1 Analysis of the Variations of the Prevalence of Infections with Helminths by Age of the Children

Investigations of the distribution of helminths infections by age of the study participants showed that a higher proportion of older children (36-59 complete months) harbored *S. mansoni* when compared to their counterparts (<3 years) (28.6% vs. 12.5% respectively, p=0.039). Moreover, *S. haematobium* infections were more prevalent among the older children than among their younger equals (32.1% against

15.4% respectively, p=0.045). Children who were diagnosed with either one or both species of schistosome comprised 21.2% of the children in the younger age group and 53.6% of children in the older age category (p=0.001). The distribution of STH infestations including hookworm, *A. lumbricoides* and *T. trichiura* did not vary significantly with the age of the study participants (Table 4.4).

Table 4.4: Parasitic Infections According to Age of the Study Participants

Parasite	**Age [n (%)]**		**P-value**
	< 3 years	**3- <5 years**	
S. mansoni			
Positive	13(12.5)	8(28.6)	**0.039**
Negative	91(87.5)	20(71.4)	
S. haematobium			
Positive	16(15.4)	9(32.1)	**0.045**
Negative	88(84.6)	19(67.9)	
Schistosome infection			
Positive	22(21.2)	15(53.6)	**0.001**
Negative	82(78.8)	13(46.4)	
Any STH			
Positive	15(14.4)	2(7.1)	0.307
Negative	89(85.6)	26(92.9)	
A. lumbricoides			
Positive	7(6.7)	2(7.1)	0.939
Negative	97(93.3)	26(92.9)	
Hookworm			

Positive	3(2.9)	3(10.7)	0.077
Negative	101(97.1)	25(89.3)	
T. trichiura			
Positive	1(1.0)	1(3.6)	0.316
Negative	103(99.0)	27(96.4)	
Malaria			
Positive	3(2.9)	0(0.0)	0.363
Negative	101(97.1)	28(100.0)	

4.3.2 Distribution of the Infections with Helminths by the Sex

The findings of the examination of the parasitic infections by sex are displayed in Table 4.5. Significantly more males than females were positive for *S. mansoni* (22.5% versus 8.2% respectively, p=0.025), *S. haematobium* (respectively, 25.4% and 11.5%, p=0.042) and overall schistosome infection (38.0% in males and 16.4% in females, p=0.006). The prevalences of malaria and STH infections were no different when analyzed by gender.

Table 4.5: Results of the analysis of parasitic infections and the sex of the study participants

Parasite	**Sex [n (%)]**		**P-value**
	Male	**Female**	
S. mansoni			
Positive	16(22.5)	5(8.2)	**0.025**
Negative	55(77.5)	56(91.8)	
S. haematobium			
Positive	18(25.4)	7(11.5)	**0.042**
Negative	53(74.6)	54(88.5)	
Schistosome infection			
Positive	27(38.0)	10(16.4)	**0.006**
Negative	44(62.0)	51(83.6)	
Any STH			
Positive	10(14.1)	7(11.5)	0.655
Negative	61(85.9)	54(88.5)	
A. lumbricoides			
Positive	5(7.0)	4(6.6)	0.912
Negative	66(93.0)	57(93.4)	
Hookworm			
Positive	4(5.6)	2(3.3)	0.517
Negative	67(94.4)	59(96.7)	
T. trichiura			
Positive	2(2.8)	0(0.0)	0.187
Negative	69(97.2)	61(100.0)	
Malaria			
Positive	1(1.4)	2(3.3)	0.472
Negative	70(98.6)	59(96.7)	

4.3.3 Intensity of Parasites Infections of the Enrolled Children

The intensity of *S. haematobium* infections varied from a minimum of 4 eggs/10ml of urine to a maximum of 98 eggs/10ml of urine (mean± standard error of intensity: 32.4 ± 4.94 eggs/10ml of urine sample). Of the 25 participants infected with *S. haematobium*, 20 (80.0%) and 5 (20.0%) children had light intensity (1 to 49 eggs/10 ml of urine sample) and heavy (≥50 eggs/10 ml urine) respectively. Twenty one children tested positive for *S. mansoni* of which sixteen (76.2%) had light intensity, (ranging from 1-99 eggs per gram (EPG) of stool sample), while five (23.8%) children had moderate intensity infections (100 - 399 epg). The mean± standard error intensity of *S. mansoni* was 71.7 ± 12.88 epg of stool (range 12 – 240 epg). All the other STH infections demonstrated light intensity as seen in table 4.6;

Table 4.6: Intensity of helminthic infestations among participants

Parasite	**Intensity**	**Number**	**%**
Hookworm (n=6)	Light (1-1,999 epg)	6	100.0
	Moderate (2,000 - 3,999 epg)	0	0.0
	Heavy (≥4,000 epg)	0	0.0
A. lumbricoides (n=9)	Light (1-4,999 epg)	9	100.0
	Moderate (5,000 - 49,999 epg)	0	0.0
	Heavy (≥50,000 epg)	0	0.0
T. trichiura (n=2)	Light (1-999 epg)	2	100.0
	Moderate (1,000 - 9,999 epg)	0	0.0
	Heavy (≥10,000 epg)	0	0.0
S. mansoni (n=21)	Light (1-99 epg)	16	76.2
	Moderate (100 - 399 epg)	5	23.8
	Heavy (≥400 epg)	0	0.0
S. haematobium (n=25)	Light (1-49 eggs/10 ml urine)	20	80.0
	Heavy (≥50 eggs/10 ml urine)	5	20.0

4.4 Association between Schistosomiasis and Nutritional Status of the Study Participants

Table 4.7 shows the results of the effects of schistosome infections as far as nutritional status of the children is concerned. Stunting was significantly associated with schistosomiasis with prevalence of schistosome infections being higher in children who were stunted compared to the ones who were not stunted (52.2% against 22.9% respectively, OR 3.665 (95% CI 1.443 - 9.309), p=.005). Additionally, children who were underweight had approximately nine-fold higher odds of being diagnosed with schistosomiasis (OR= 8.460 (95% CI 2.105 - 33.999), p = 0.001).

The prevalence of anemia was significantly higher among those who were diagnosed with schistosome infections when compared to those tested negative with the former having about three-fold higher odds of being anemic (57.1% versus 14.4% respectively, OR 7.897, p< 0.001). Furthermore, there were significant variations in the haemoglobin concentrations between the two groups (infected and non-infected) (mean ± standard error (SE): 10.8 ± 0.15 g/dl against 11.9 ± 0.10 g/dl for those who were positive and negative for schistosomiasis, respectively, p < 0.001).

Thinness as demonstrated by BMI for age z-scores was insignificantly connected with prevalence of schistosomiasis (OR 0.696 (95% CI 0.412-0.657), p=0.412). Additionally, wasting and MUAC were not significant predictors of the schistosomiasis infection status in the study group (p=0.451 and p=0.381 respectively).

Table 4.7: Assessment of the effect of schistosome infections on the nutritional status

Nutritional status	Schistosomiasis		OR (95% CI)	P-value
	Positive [n (%)]	Negative [n (%)]		
Weight-for-length/height z- scores				
Wasting (< -2 z-scores)	7(35.0)	13(65.0)	1.472(0.536-4.039)	0.451
Normal (≥ -2 z-scores)	30(26.8)	82(73.2)	REF	
Length/height-for-age z-scores				
Stunting (< -2 z-scores)	12(52.2)	11(47.8)	3.665(1.443-9.309)	**0.005**
Normal (≥ -2 z-scores)	25(22.9)	84(77.1)	REF	
Weight-for-age z-scores				
Underweight (< -2 z-scores)	8(72.7)	3(27.3)	8.460(2.105-33.999)	**0.001**
Normal (≥ -2 z-scores)	29(24.0)	92(76.0)	REF	
BMI-for-age z-scores				
Thin (< -2 z-scores)	9(23.1)	30(76.9)	0.696(0.293-1.657)	0.412
Normal (≥ -2 z-scores)	28(30.1)	65(69.9)	REF	
MUAC Z scores				
Low (< -2 z-scores)	4(40.0)	6(60.0)	1.798(0.477-6.776)	0.381
Normal (≥ -2 z-scores)	33(27.0)	89(73.0)	REF	
Anaemia Status				
Anemia (Hb<11 g/dl)	24(57.1)	18(42.9)	7.897(3.383-18.438)	**<0.001**
Normal (Hb≥11 g/dl)	13(14.4)	77(85.6)	REF	

CHAPTER FIVE

5.0 DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Discussion

The findings from the current cross sectional survey highlights a significant burden of infections with Schistosomes among children under 5 years living in the study area. In this study, approximately one-tenth of the participants had concurrent Schistosome infections while one-quarter of the children had infections with *S. haematobium*. One out of every five participants examined was positive for infection with *S. mansoni*. Besides, STH infections were reported in more than one-tenth of the children who participated in the study. The findings add to the growing body of evidence supporting the call for inclusion of children under 5 years of age in the schistosomiasis and soil transmitted helminthiasis control programs.

A review of literature indicates wide variations in estimates of the burden of bilharziasis and intestinal nematode infections in children under the age of 5 years (Sacolo-Gwebu *et al*., 2019; Kalinda *et al*., 2020; Mazigo *et al*., 2021). This could be explained by the differences in both environmental and host specific factors that may impact on the transmission of these infections. These may include population heterogeneity, genetics, age, poly-parasitism, temporal aspects, geographic settings, parasitological method used, personal hygiene practices, climate and altitude among others. This study has highlighted the prevalence of both single and dual schistosome infections and other soil transmitted helminthes infection among the under 5 years' children in, Taita/Taveta County.

5.1.1 Prevalence and Intensity of Schistosome Infection among Children Under 5 Years in Taita Taveta County

The prevalence of urinary schistosomiasis recorded in this study (18.9% 95% CI 13.2%-26.5%) is no different compared to the 19.8% reported by a team led by Opara in a research that focused on pre-school children in Nigeria (Opara *et al.,* 2012). However, our estimate is slightly higher compared to the prevalence of 11.2% reported among infants in Ghana (Bosompem *et al*., 2014). The Ghanaian study recruited much younger children compared to our study (included children aged six months and below) and this may be one of the reason for the discordance in the findings. The younger children have lesser exposure to the infections compared to the elder ones hence a lower likelihood of being infected.

S. mansoni in children under 5 years whose prevalence (15.9%) was lower compared to surveys done from western Kenya which were 16.3% and 38.8% (Nagi *et al*., 2014; Chadeka *et al*.,2019) respectively but was over higher compared to a survey done in Uganda of 4.1% (Nalugwa *et al*., 2017). The varying differences of the prevalence, may be associated with the close proximity of schools to water bodies and households in the villages as has been reported elsewhere (Abere *et al.,* 2020; Musuva *et al.,* 2021). In the present study, households and villages selected happen to have been in close proximity to canals and/or rivers flowing temporally towards Lake Jipe. The increased prevalence rates of schistosomiasis infection among schools which are near water sources in this study demonstrates the main distinctive characteristic of schistosomiasis in endemic areas.

Other research on such infections on young population below the age of 5 years old conducted in Tanzania reported findings which are in concordance with those of the current study with schistosomiasis being the common infection (prevalence 15.8%; 95% CI 12.1 - 20.3%). However, the Tanzanian study reported a significantly lower burden of *S. haematobium* infections (1.0%) (Said *et al*., 2017). The dissimilarities in the findings between the two studies could also be a reflection of the differences in the distribution of the specific intermediate hosts of *S. haematobium* (*Bulinus spp.*) in the two study sites.

About 6.8% of children harbored both mansoni and haematobium species, however, Adel *et al*., (2008) reported a 45% prevalence among school age children in Kiwalwa primary school in Taita Taveta County. The high infection rate in school going children may be attributed to the different water associated activities in the villages. However, the 5 years' national school based deworming programme conducted by the Ministry of Health and Ministry of Education may have interrupted the intense transmission in these areas. This then may be an indication that the government efforts have been successful.

Generally, heavy intensity infections with helminths (both schistosome and STH) were not common among the participants who took part in our study. Only five PSAC (3.8%) had infections of heavy intensity and these were specifically *S. haematobium* infections. Analogous observations were made by a research conducted in Uganda which noted no heavy intensity infections with ascariasis and trichuriasis among PSAC (Ojja *et* al., 2018). However, the prevalence of heavy-intensity with *Ascaris lumbricoides* and *Trichuris trichiura* was 18.2% and 11.7% respectively, in a study

that involved PSAC in Philippines (Belizario Jr *et* al., 2015). In discordance with the Philippian's study findings, no heavy-intensity hookworm infections were observed in the current research.

Research among PSAC in Mbita Causeway, Homa Bay, Kenya reported the following proportion of intensities of infections with *S. mansoni*: light 28.9% (95% CI 25.8%-32.0%), moderate 10.6% (95% CI 8.4%-12.7%) and heavy 5.7% (4.1%-7.3%) (Chadeka *et* al., 2019). The infections with STH were all of light intensity. The dissimilarity in these findings with those of the present survey could be attributed to the differences of contact patterns of humans to cercaria infested waters, the availability and abundance of competent intermediate host snail, suitable habitats for the intermediate snail hosts, level of freshwater contamination with stool and/or urine containing eggs with miracidium and also the variations of immunity of human hosts.

Total number of children infected with STH was very low in this study and this may be facilitated by continuous deworming of young children when they are taken to the ante-natal clinic. It should also be noted that the Ministry of Health conducts annual national deworming of children under 5 years during Malezi bora campaigns where children are given anti-helminthic drugs (Oiye *et al*., 2019).

Our finding on hookworm prevalence (4.5%) was much higher compared to what was reported in rural Kwa zulu-natal, South Africa where prevalence of hookworm was 1.6%. The South African study, however, found higher prevalence of *Ascaris lumbricoides* (18.3%). On the other hand, the prevalence of *Trichuris trichiura* (1.2%)

in that study was not very different from what was found in the present study (Sacolo-Gwebu *et* al., 2019).

This present data supports key observations that regular deworming for the children aged ≤5years through the Integrated Management of Childhood illnesses (IMCI) available in all government health facilities in Kenya reduces the burden of helminthes infections in the community (Reñosa *et al*., 2020).

5.1.2 Relationship between Schistosomiasis Infection and Anemia in Children under 5 Years in Taita Taveta County

Chronic anemia acquired in early in life is related with impairments on overall poor growth, cognitive development and to an extent poor school performance later in life. Besides Severe anemia is a major cause of sickness and death among children in sub-Saharan Africa (English. M *et al.*, 2002) This study demonstrated that approximately one-third of the studied participants had been diagnosed as having anemia and the burden of anemia was higher among those who tested positive for the schistosome infections.

This agrees very well with a survey conducted in Niger, which alluded that *Schistosoma haematobium* infections accelerated the risk of anemia by 30% (Garba *et* al., 2010). Similarly, a survey from Tanzania, revealed that the concentration of hemoglobin in infected children was 0.4 g/dl lower than those participants who were uninfected (Bhargava *et* al., 2004). These findings also compare well with those in Uganda where the study revealed a significantly higher proportion of intestinal schistosomiasis positive children were anemic (52.3% in the infected group and 35.2% in the uninfected group, $p<0.005$). The results are consistent with the

conventional knowledge that schistosomiasis is among the myriad causes of anemia (Nalugwa *et al*., 2017). Even though malaria and hookworm infections are also known to cause anemia, their prevalence, in the present study, was marginal. Moreover, the intensities of infections with hookworm were low. These findings are not surprising because malaria and hookworm infections are not common in children under five years of age; rather they are more prevalent in adults and older children. Despite the area being relatively rich in nutritional foods, anemia is still common among children under 5 years. Part of this may be associated with parasite infection and/or parental knowledge on proper nutritional dieting.

5.1.3 Association between Schistosomiasis and Nutritional Status of the Study Participants Enrolled at Taita/Taveta County

About one out of every five participants who took part in the study was stunted. Stunting was more prevalent in PSAC who had Schistosome infections. In addition, approximately one-tenth of the children were underweight with higher odds of being underweight being recorded among participants under 5 years in the schistosomiasis positive group.

A study done in Zimbabwe among children under 5 years indicated higher prevalence's of malnutrition in this age group; underweight (prevalence 10.1% (95% CI 8.5% to 11.9%), and stunted growth (Prevalence 18.0% (95% CI 16.0% to 20.3%). Consistent with the present study findings, the Zimbabwean study found that, on comparing infected and uninfected children, cases of stunted growth, underweight and to an extent wasting was remarkably elevated in PSAC who had schistosome

infections (27.0%; 95% CI 19.9% to 35.6% and 17.0%; 95% CI 14.9% to 19.4% respectively, p=0.009) (Osakunor *et* al., 2018).

The proportion of PSAC who were stunted, underweight and exhibiting wasting/thinness was 39.5%, 22.8% and 11.4% respectively according to a study done in Southwest Nigeria (Adeniran *et* al., 2017). In this survey, there was no significant association between nutritional indicators and both intestinal schistosomiasis and soil transmitted helminthiasis. The wide disparities in findings most probably mirrors the socio-economic status in the study settings.

The current study is not without limitations. The history of deworming of the children who were studied was not recorded and this represents a potential confounder in the relationships that were investigated in the current study. Additionally, due to resource limitations, only one sample was taken from the study participants. This could have led to under-estimation of the actual burden of helminthiases. Furthermore, the diagnostic method used in the study (Kato Katz technique) is not considered to be highly sensitive, particularly in low intensity infections (Katz *et* al., 1972).

5.2 Conclusion

A significant burden of schistosomiasis and STH among children aged less than five years was observed in the study area. The study demonstrates unequivocally that the PSAC in this area need to be prioritized for interventions including mass treatment. For example, in line with WHO recommendations, since the egg patent prevalence of schistosomiasis in this age group is within the WHO-defined range of more than 10% but not exceeding 50%, then biennial treatment with praziquantel should be

conducted. With the WHO's ambitious goal of reaching 75% coverage of preventive chemotherapy targeting major helminthiases among PSAC, the findings from this study emphasizes the need for urgent planning and implementation of specific interventions to prevent further morbidity and to improve health of children. Our data support the call for institutionalized MDA in lieu of school-based approaches only. This will ensure that deserving PSAC are reached by pertinent interventions via alternative delivery platforms such as through the Integrated Management of Childhood Illnesses and through ECDEC.

The study established that schistosomiasis and STH infections are prevalent in children less than 5 years Taita Taveta County thus presenting a potentially significant public health problem. Anaemia and nutritional deficiency has also been associated with schistosomiasis in the infected children. The present study has reported for the first time, the prevalence of dual (*S. mansoni* and *S haematobium*) infection in children less than 5 years.

5.3 Recommendations

Since the study demonstrated unequivocally that the PSAC in this area are at risk of *S. mansoni* and *S. haematobium* infection, they need to be prioritized for various public health interventions including mass treatment. For example, in line with WHO recommendations, since the egg patent prevalence of schistosomiasis in this age group is within the WHO-defined range of more than 10% but not exceeding 50%, then biennial treatment with praziquantel should be conducted (WHO, 2006). With the WHO's ambitious goal of reaching 75% coverage of preventive chemotherapy targeting major helminthiases among PSAC (WHO, 2012), the findings from this

study emphasizes the need for urgent planning and implementation of specific interventions to prevent further morbidity and to improve health of children. Our data support the call for institutionalized MDA in lieu of school-based approaches only. This will ensure that deserving PSAC are reached by pertinent interventions via alternative delivery platforms such as through the Integrated Management of Childhood Illnesses and through ECDEC.

From the results of this study, we recommend that children under 5 years be treated for schistosomiasis using syrup formulation of Praziquantel to reduce subtle morbidity, poor nutritional outcomes and possible transmission in endemic areas.

5.4 Further Research

Numerous projected guidelines by the world health organization have emerged for endorsing treatment of young and growing children in the most endemic areas. However, publication on the performance of the effective drug praziquantel in children below the age of 5 years has been minimal. More scientific work should be done at the study area to bring out the greater picture of praziquantel to pre-school-age population residing in endemic areas is actually safe for use.

This great work will clarify on other key undertakings like coming up with the syrup praziquantel for this age group which currently has not been explored fully knowing very well that this drug which is effective against schistosomiasis is available in tablets form only. Several writers have published a lot regarding to schistosomiasis in pre-school-aged children though no detailed and documented follow-up of the children and their mothers including growth and nutritional status has been done.

However, there has been heavy exposure to Praziquantel to cure schistosomiasis in developing nations but equally there are emerging reports of *S. mansoni* and *S. haematobium* resistant to treatment. This has propagated the search for possible vaccines, alternative cure and other possible control approaches.

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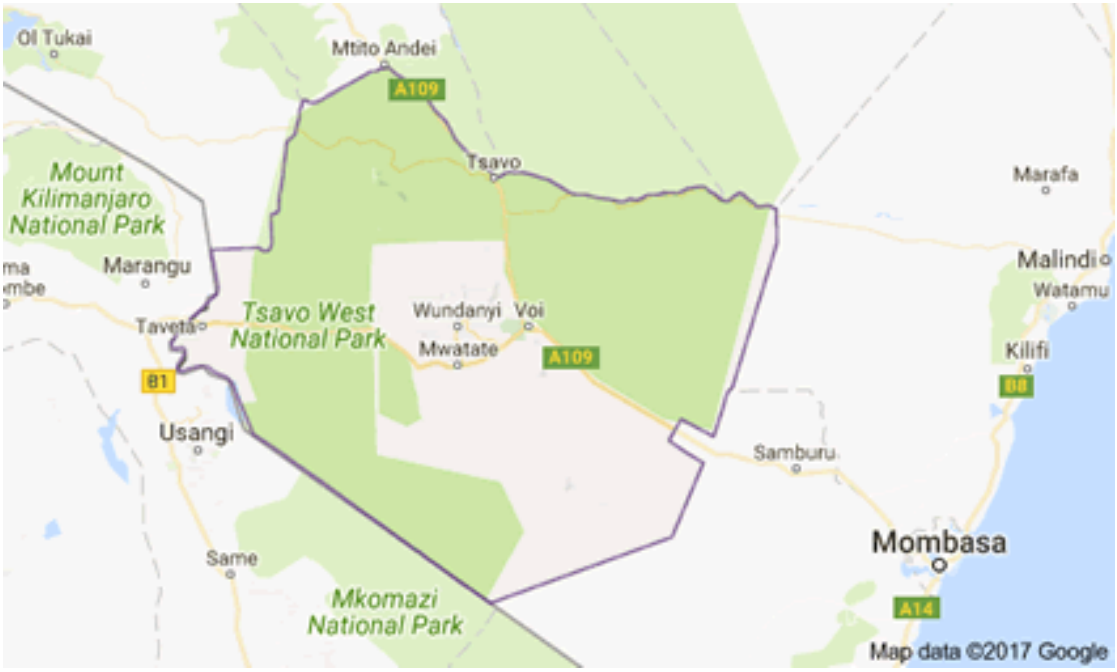
APPENDICES

Appendix I: Map for Taita Taveta County



Appendix II: Data Collection Sheet

TITLE: THE EFFECT OF SCHISTOSOMIASIS ON THE HEMOGLOBIN CONCENTRATION AND NUTRITIONAL STATUS IN CHILDREN UNDER 5 YEARS, TAVETA SUB - COUNTY.

RAW DATA COLLECTION TOOL

INDEX	GENDER	MEASUREMENTS			SPECIMEN TAKEN (tick if taken)					Specimen collected by:	Laboratory results			Date	Techs name

Appendix III: Ethical Approval

KENYATTA UNIVERSITY
ETHICS REVIEW COMMITTEE

Fax: 8711242/8711575
Email: kuerc.chairman@ku.ac.ke

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

Website: www.ku.ac.ke

Our Ref: **KU/ERC/ APPROVAL/VOL.1 /274** Date: 9th July, 2019

Paul Ngaluma Nyika
P.O Box 43844, 00100
Nairobi.

Dear, Mr. Nyika

APPLICATION NUMBER: PKU/1026/I1076 EFFECTS OF SCHISTOMIASIS ON HEMOGLOBIN CONCENTRATION AND NUTRITIONAL STATUS IN CHILDREN UNDER 5 YEARS, TAITA/TAVETA COUNTY, KENYA

1. **IDENTIFICATION OF PROTOCOL**

The application before the committee is with a research topic **"Effects of Schistomiasis on Hemoglobin Concentration and Nutritional Status in Children under 5 Years, Taita/Taveta County, Kenya"**. Received on 3th May, 2019 and discussed on 11th June, 2019

2. **APPLICANT**

Paul Ngaluma Nyika

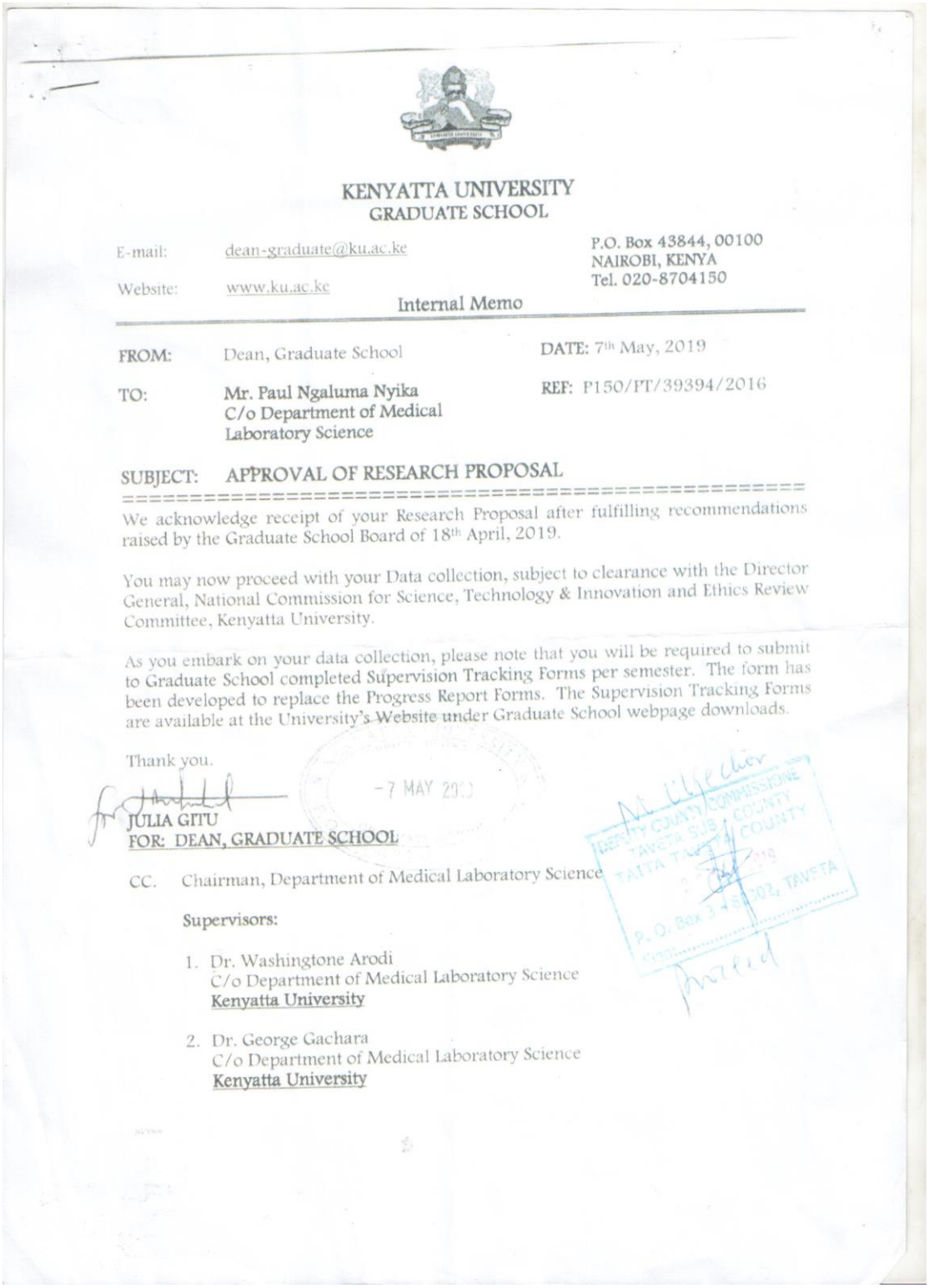
3. **SITE**

Taita/Taveta County, Kenya

4. **DECISION**

The committee has considered the research protocol in accordance with the Kenyatta University Research Policy (section 7.2.1.3) and the Kenyatta University Ethics Review Committee Guidelines and **APPROVED that the research may proceed for a period of ONE year from 11th June, 2019.**

Appendix IV: Graduate School Approval



KENYATTA UNIVERSITY
GRADUATE SCHOOL

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

P.O. Box 43844, 00100
NAIROBI, KENYA
Tel. 020-8704150

Internal Memo

FROM: Dean, Graduate School

DATE: 7th May, 2019

TO: Mr. Paul Ngaluma Nyika
C/o Department of Medical
Laboratory Science

REF: P150/PT/39394/2016

SUBJECT: APPROVAL OF RESEARCH PROPOSAL

We acknowledge receipt of your Research Proposal after fulfilling recommendations raised by the Graduate School Board of 18th April, 2019.

You may now proceed with your Data collection, subject to clearance with the Director General, National Commission for Science, Technology & Innovation and Ethics Review Committee, Kenyatta University.

As you embark on your data collection, please note that you will be required to submit to Graduate School completed Supervision Tracking Forms per semester. The form has been developed to replace the Progress Report Forms. The Supervision Tracking Forms are available at the University's Website under Graduate School webpage downloads.

Thank you.

-7 MAY 20

JULIA GITU
FOR: DEAN, GRADUATE SCHOOL

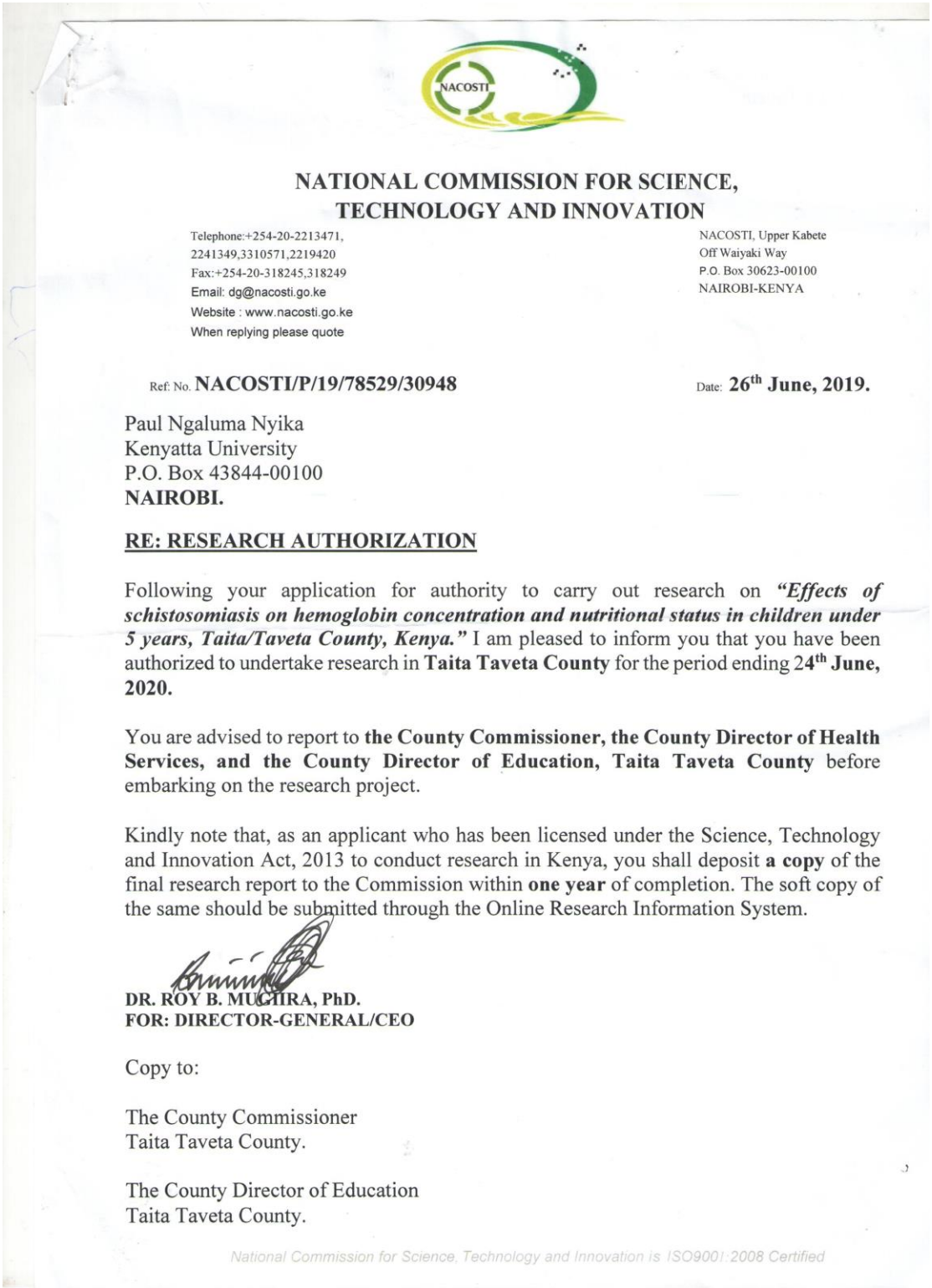
CC. Chairman, Department of Medical Laboratory Science

Supervisors:

1. Dr. Washingtone Arodi
   C/o Department of Medical Laboratory Science
   Kenyatta University

2. Dr. George Gachara
   C/o Department of Medical Laboratory Science
   Kenyatta University

Appendix V: Research Permit



NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

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NACOSTI, Upper Kabete
Off Waiyaki Way
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No. **NACOSTI/P/19/78529/30948**

Date: **26th June, 2019.**

Paul Ngaluma Nyika
Kenyatta University
P.O. Box 43844-00100
NAIROBI.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Effects of schistosomiasis on hemoglobin concentration and nutritional status in children under 5 years, Taita/Taveta County, Kenya."*** I am pleased to inform you that you have been authorized to undertake research in **Taita Taveta County** for the period ending **24th June, 2020.**

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

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

DR. ROY B. MUGHIRA, PhD.
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Taita Taveta County.

The County Director of Education
Taita Taveta County.

Appendix VI: Sub-County Hospital Approval

Noted
Approved and
can be
proceed with
the
Project

MEDICAL SUPERINTENDENT
MINISTRY OF HEALTH
TAVETA SUB-COUNTY HOSPITAL
P.O. BOX 31 TAVETA

Paul NgalumaNyika,
P.O Box 202,
Taveta.
Email:Paulngaluma58@gmail.com,
Phone: +254724067678,

13th May, 2019.

The Medical Superintendent,
Taveta Sub- County Hospital,
P.O. Box 31-80302,
Taveta.

Dear Sir/Madam,

RE APPLICATION TO UNDERTAKE A M.SC. PROJECT AT TAVETA SUB-COUNTY HOSPITAL.

The above subject refers.

I am a Master of Science (Infectious Diseases) student at Kenyatta University, registration number P150/PT/39394/2016, and I am undertaking a project entitled ***'Effects of schistosomiasis on hemoglobin concentration and nutritional status in children under 5 years,Taita/Taveta County,Kenya'***. The study will comprise collecting specimens from key study respondents from the general area of Mboghoni and Bomeni wards while laboratory diagnosis will be carried out at Taveta Sub- County hospital laboratory facility.

The hospital will not incur any expenses towards this study in any way as most of the reagents, consumables and auxiliary equipment's intended for use during the data collection period will be shipped into the laboratory by the principal investigator.

This is therefore, to kindly submit my application foryour consideration and approval before carrying out my research. My supervisors are Dr. Washington Arodi phone number: 0764505224and email address: arodi.washington@ku.ac.ke and Dr. George Gachara of phone number0722759578 and email address:ggachara@gmail.com.

I am willing to provide further information if need be.

Thank you and am looking forward to your correspondence.

Yours Sincerely,

Paul Ngaluma.

Appendix VII: Consent Form

INFORMED CONSENT FORM – Parent/Guardian (English version)

Study Title: Effects of schistosomiasis on haemoglobin concentration and nutritional status in children under 5 years, Taita/Taveta County.

Study Sponsor: Personal

Investigator: Paul Ngaluma Nyika

Institution: Taveta Sub- County hospital

Introduction: A study is being done by the above mentioned Scientist in Taveta looking at the types of parasites that cause Schistosomiasis. A Laboratory examination has found that your child has an infection that's why I will like to tell you more about the study answer any of your questions and invite your child to take part in the study.

Purpose of the study: This study wants to find whether the schistosomal infection can lead to anemia in children under 5 years in the community. This information will help the health sector to treat this infection and help us to understand how to stop them from spreading in our communities in Kenya and the world in general.

Enrollment requirements: Anyone younger than 5 years of age who have been identified can join and take part of the study

Study duration: This study will be going for a period of 4 weeks and we hope to be able to test over 100 samples. If you accept to be part of the study you will indicate your agreement by signing the consent form or providing a thumb print if you cannot write. Your child will only be allowed to participate in the study after consenting.

Participation and withdrawal from the study: You are free to choose if your child will take part in the study or not. Your child can seize participating at any point in

time, for any reason by telling the study staff. If you do not agree for us to continue using the sample collected from your child, they will be destroyed.

Compensation: Other than medical care that may be provided there is no other compensation available for your child participation in this research.

Cost of participation: There is no cost for taking part in the study.

Confidentiality: Your child's personal information will not be shown to anyone and only a study code will be put on all your child samples and information sheets. The study results will only be shared with the participating hospital and the ministry of health. The results will be written in a scientific journal and no information that can be used to identify your child will be used.

Study Procedure: Some information from your child will be needed, some measurements like height, weight will be taken while questions about your child's age, sex and locality will be needed too. The following specimens will be collected for Laboratory diagnosis purposes;

- Stool Specimen: This will be collected in a clean polypot
- Urine Specimen: Your child will pass urine into a collecting sterile container
- Blood Smears: The blood collection will involve a needle prick which may cause just a little bit of pain.

Risks of the study: We will take some of your child's time to collect the above mentioned specimens however despite the little pain that will be experienced during the blood prick, we do not expect to harm your child in any way.

Questions: If you have any questions about the study, your child being in the study or you think your child has been hurt as a result of being in the study you may call or

email the main study researcher Paul Ngaluma at 0724067678 or paulngaluma58@gmail.com. Or in case of any questions you may feel free and contact Dr. Washington Arodi, Tel 0733805224 or Dr. George Gachara Tel, 0722759578 or Kenyatta University ERC Secretariat at; secretary kuerc@ku.ac.ke or Ercku2008@gmail.com.

Consenting statement:

I have read this consent form (or it has been read to me), it has been explained to me why this study is being performed, and i feel that all my questions have been answered. I have chosen freely for my child to participate in this research. It has been clarified to me that when i sign this form i do not give up my child's rights or release the researchers from doing the things they should do for my child as a study participant.

As part of this study I agree for:

a) The researcher to find parasites in my child's specimens and a possible treatment to my child.
b) The researcher to share my child's information to the Ministry of Health.
c) Results from my child's specimen to be put in a medical journal articles, scientific meetings, and conference presentations however my child's name and other information that could tell someone who your child is will not be used.

Parent/Guardian name……..Date……...…Sign……..……

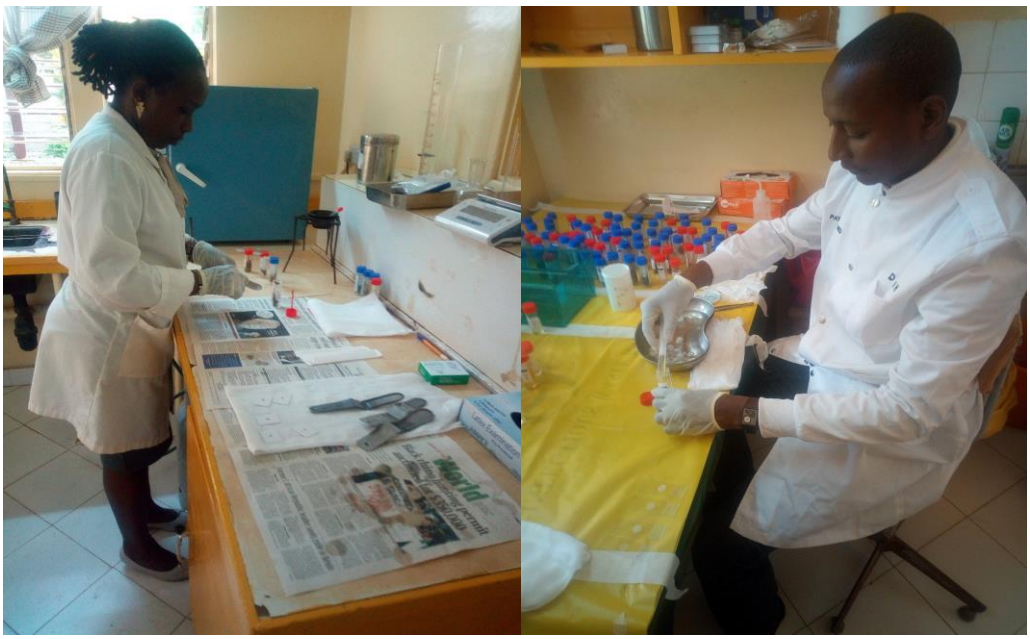
Parent/Guardian Telephone number…….

Consenter name:……..Date……Sign……..

Appendix VIII: Photo Plates

Researcher – Paul Ngaluma (left) sensitizing the local women in a health facility about the study (right) receiving and cross-checking out urine and stool specimens for pre-analytical errors

Researcher – Paul Ngaluma (left) obtaining capillary blood specimen from the respondent (right) facility nurse facilitating and collecting MUAC measurements from the study participants



Laboratory technologist – Miriam Mwadime (left) and the researcher (right) processing the stool and urine specimens for Kato Katz and Urine filtration technique respectively.

Appendix IX: Published Manuscript

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Journal of Infectious Diseases and Diagnosis

Research

Schistosomiasis and Soil Transmitted Helminthiases in Taita Taveta County, Kenya: Prevalence, Intensity and Association with Anaemia and Nutritional Status of Children under 5 Years

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ABSTRACT

With delayed treatment, schistosome and soil transmitted helminth (STH) infections in young children (<5 years) could potentially lead to irreversible lifelong detrimental health effects. This is because these infections are known to cause suboptimal growth and development in this critical phase of life. The present study sought to document the burden of schistosome and STH infections in Taita Taveta County, Kenya, by determining the prevalence and intensity of the infections in children less than 5 years of age. The study also appraised the association between infections with schistosomes, anaemia and nutritional status in children. A total of 132 children, 53.8% males, were enrolled in the survey. The number of children who were diagnosed with schistosomiasis was 37 (prevalence 28.0%; 95% confidence interval (CI) 21.1%-36.2%). Infections with *S. haematobium* and *S. mansoni* were detected in 18.9% (95% CI 13.2%-26.5%) and 15.9% (95% CI 10.7%-23.1%) of the surveyed children, respectively. Seventeen children tested positive for infection with any STH (prevalence 6.8%; 95% CI 3.6%-12.5%). Species-specific prevalences of STH were: *A. lumbricoides* (6.8%), hookworm (4.5%) and *T. trichiura* (1.5%). Four children (16.0%) had heavy intensity *S. haematobium* infections. No heavy intensity infections were detected in children who were infected with STH and *S. mansoni*. Nutritional indices which were associated with schistosome infections included stunting ((odds ratio (OR) 3.665 (95% CI 1.443-9.309), p=0.006) and being underweight (OR 12.698 (95% CI 3.107-51.900, p<0.001). Anaemia was more prevalent among children who tested positive for infections with schistosomes when compared with their schistosome-negative counterparts (57.1% vs. 42.9% respectively, OR 7.897 (95% CI 3.383-18.438), p<0.001). The study established that schistosome and STH infections are prevalent in children under 5 years in the study area thus presenting a potentially significant public health concern. The children should be prioritized for interventions including being incorporated in the mass deworming programme which currently targets school age children.

Keywords: Soil-transmitted helminths; Schistosomiasis; Mass drug administration; Neglected tropical diseases; Nutritional status; Anaemia; Children under 5 years

AUTHOR SUMMARY

Research has demonstrated that young children (less than 5 years) suffer from schistosomiasis and soil transmitted helminthiases (STH) in regions where the two diseases occur together. In spite of this, no interventions have been put in place to address this challenge. Current schistosomiasis and STH control programs focus exclusively on school-aged children. As a result the young children who are infected only receive treatment

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on attaining school age. By this time, significant negative health effects will have taken place. Furthermore lack of treatment for this group contributes considerably to the sustenance and transmission of the infections in the community. The current study confirmed schistosomiasis and STH to be prevalent among the young children thus adding to the accumulating body of evidence highlighting the substantial burden of the two diseases and the need to institute appropriate remedial measures. Specifically, this study emphasizes the urgent need to integrate the young children in the current efforts aimed at preventing and controlling these diseases including the ongoing mass drug administration programme.

INTRODUCTION

Infection with schistosome and soil transmitted helminths (STH) remain a key public health challenge in sub-Saharan Africa. The two infections are closely linked to poverty in addition to inadequate safe water, sanitation and hygiene [1]. Though these infections are prevalent in all age groups, preschool age children (PSAC), school age children (SAC) and women of reproductive age are considered to be at high risk of morbidities associated with STH and schistosome infections [2]. Chronic infections with STH and schistosomes compromise growth, development, cognition, iron status and naivety of immune system which further increase susceptibility to infections [3]. Blood losses from haematuria and faecal occult blood from schistosome infections affects iron balance causing anaemia. Additionally, STH given their distinctive niche perpetually deprive the host vital nutrients [4]. Research studies in PSAC have demonstrated that STH and schistosome infections occur in early childhood, and if untreated can lead to undesirable health consequences later in life [5,6]. Furthermore, it has been observed that a substantial population of PSAC are at risk of infections with schistosomes and STH. For instance, according to Albonico and colleagues [3] about 10% to 20% of the 3.5 billion people residing in areas where STH endemic are PSAC.

Furthermore, it is estimated that out of the 123 million children suffering from schistosome infections worldwide, about 50 million are PSAC [7]. Despite PSAC being classified as a group at high risk of morbidities linked with schistosome and STH infections, the main focus for treatment has been SAC [2]. Dearth of published research on the burden of schistosome and STH infections in PSAC is to blame, at least partially, for the exclusion of this age group from the current programs aimed at controlling and eliminating infections with schistosomes and STH. This is of great concern bearing in mind that PSAC are nutritionally vulnerable section of the population and defects arising during this developmental stage may persist for long and sometimes throughout life [4]. The present study aimed to determine the prevalence and intensities of infections with schistosome and STH among PSAC in an area which is known to be endemic for the two infections [8-10]. The study also examined the burden of anaemia in this age group as well as growth and nutrition-related morbidities associated with schistosome and STH infections.

METHODS

Ethical statement

Relevant scientific and ethical reviews and approvals were provided by the Kenyatta University. Written informed consents were obtained from the mothers whose children participated in the study. Permission to undertake the study was granted by the Ministry of Health (MoH), Taita Taveta County. All children who were found positive for infections with schistosomes and/or STH were treated in a local public health facility according to MoH guidelines.

Study site

The study was conducted at Taveta Sub-county of Taita Taveta County. Taita Taveta County is one of the six Counties in the Coastal region of Kenya. It is located approximately 200 Km northwest of the coastal city of Mombasa and 360 km southeast of Nairobi, the capital city of Kenya. It borders Kitui and Makueni Counties to the North, Kwale and Kilifi Counties to the East, Kajiado County to the North-west, and the Republic of Tanzania to the South and South-west. The County covers an area of 17,084.1 Km2 and lies between latitudes 2° 46' South and 4° 10' South and longitudes 37° 36' East and 30° 14' East. As of 2019 national census, the estimated population of the county was 340,671. The population for children under five years was estimated to be 37,780 in 2009 with population projections for this age group, for 2015 and 2017, being 39,663 and 41,646 respectively [11].

Study design and population

The present health-facility based cross-sectional study design recruited children below 5 years consecutively as they sought services in public health facilities within Bomani Ward of Taveta Sub-county. The inclusion criteria included being a resident of the study area for at least 12 months and the caregiver providing consent for the child to take part in the research. Children who were critically ill were excluded from the study.

Sample and data collection procedure

Data on demographic characteristics (age and sex) and nutritional status (weight, height, length, and mid-upper arm circumference (MUAC) were captured on a data collection form as the samples were being collected. Universal bottles were provided to the parents/caregiver for collection of urine and faecal samples. The Stool samples were processed by Kato Katz technique [12]. Slides of the resultant smears were examined microscopically. Presence and number of species of parasitic eggs observed were recorded. Urine samples were collected between 1000 and 1400 hours and processed using urine filtration method as described by Mott and others [13]. Briefly, urine samples were agitated to ensure adequate dispersal of eggs. Ten mL of urine was drawn using a syringe and passed through Nucleopore-H filters. The filters were then mounted on a microscope slide. Microscopic examinations were performed and the presence and number of *S. haematobium* eggs noted. Blood samples were tested for malaria parasite antigen using SD

Bioline Malaria Ag P.f/Pan (Standard Diagnostics Inc., Korea), RDT kits as outlined in the manufacturers' instructions inserts. Haemoglobin concentration was determined using 301 HemoCue analyzer (Anglom, Sweden).

Data management and statistical analysis

Intensities of STH and schistosome infections were stratified according to the cut-offs defined by the WHO guidelines [2]. Anaemia was defined as hemoglobin<11 g/dl [14]. Appropriate anthropometric indices including weight-for-age z-scores (WAZ), weight-for-height z-scores (WHZ) and height-for-age z-scores (HAZ) were computed based on WHO's child growth standards [15]. Analysis of nutritional data was performed using WHO Anthro 3.2.2. Other statistical analyses were done using IBM SPSS Statistics 22.0. Normally distributed continuous data were described using mean ± standard deviation (sd). Continuous data which were not normally distributed were described using median and interquartile range (IQR). Categorical variables were described using absolute numbers and corresponding proportions. Chi-square ($\chi 2$) test, or Fisher's exact test where appropriate, were used to test associations between the independent variables and the dependent variable. A p-value of less than 0.05 was set as the threshold of statistical significance in all hypotheses tests.

RESULTS

Demographic characteristics of the study participants

Analysis of the demographic characteristics of the 132 children (<5 years) who took part in the current survey showed that the age of the enrolled children ranged from 7 to 59 complete months. Majority of the surveyed children were male (53.8%). The median (IQR) age was 48 (39-59) months. Those who were aged between 24 and 48 months were 43.2% while those aged less than 24 months comprised 47.7% of the study participants. The rest (9.1%) were aged more than 48 months.

Nutritional status of the enrolled children

The findings on the nutritional status of the enrolled children are displayed in Table 1. Wasting and stunting was observed in 15.2% and 17.4% of the sampled children respectively. Children who were underweight comprised 8.3% of the study participants. The mean ± standard deviation (sd) haemoglobin concentration was 11.6 ± 1.25 g/dl (range: 8.7 to 16.7 g/dl). The haemoglobin concentration did not differ significantly by sex (11.6 ± 0.14 g/dl boys and 11.6 ± 0.16 g/dl for girls, p=0.922). The overall prevalence of anaemia was 31.8%. (95% CI 24.5%-40.2%). Children whose MUAC z-scores were classified as low (<-2 z scores) were 7.6%. The prevalence of thinness in the surveyed children as indicated by BMI-for-age z-scores was 29.5%.

Table 1: Nutritional status of the study participants.

Attribute	Category	Number (n=132)	%
Weight-for-length/height scores	z- Wasting (<-2 z-scores)	20	15.2
	Normal (≥ -2 z-scores)	112	84.8
Length/height-for-age z-scores	Stunting (<-2 z-scores)	23	17.4
	Normal (≥ -2 z-scores)	127	96.2
Weight-for-age z-scores	Underweight (<-2 z-scores)	11	8.3
	Normal (≥ - 2 z-scores)	121	91.7
BMI-for-age Z scores	Thin (<-2 z-scores)	39	29.5
	Normal (≥ - 2 z-scores)	93	70.5
MUAC Z scores	Low (<-2 z-scores)	10	7.6
	Normal (≥ - 2 z-scores)	122	92.4
Haemoglobin level	Anaemic (<11 g/dl)	42	31.8
	Normal (≥ 11 g/dl)	90	68.2
Haemoglobin (mean ± standard deviation)		11.6 ± 1.25 g/dl	

Prevalence of helminthic infections

The proportion of study participants who were positive for schistosomiasis was 28.0% (95% confidence interval (CI) 21.1%-36.2%). The prevalence of infections with *S. haematobium* and *S. mansoni* were 18.9% (95% CI 13.2%-26.5%) and 15.9% (95% CI 10.7%-23.1%) respectively. Infection with either of the two species of schistosomes was reported in 28 children (21.2%). Nine children had co-infections with both species of schistosomes (6.8%). A total of seventeen children were infected with any of STH species (prevalence of 12.9% (95% CI 8.2%-19.7%); Further, the prevalences of infections with STH species were as follows: *A. lumbricoides* 6.8% (95% CI 3.6%-12.5%), hookworm 4.5% (95% CI 2.1%-9.6%), and *T. trichiura* 1.5% (95% CI 0.4%-5.4%). These distribution of the infections with helminths among preschool age children is illustrated in Figure 1.

Intensity of helminthic infections

The intensity of *S. haematobium* infections varied from a minimum of 4 eggs/10 ml of urine to a maximum of 98 eggs/10 ml of urine (mean ± standard error intensity: 32.4 ± 4.94 eggs/10 ml of urine). Of the 25 children infected with *S. haematobium*, 20 (80.0%) and 5 (20.0%) children had light intensity (1-49 eggs/10 ml urine) and heavy intensity (≥ 50 eggs/10 ml urine) infections respectively. Twenty one children tested positive for *S. mansoni*, out of which sixteen (76.2%) had light intensity infections (1-99 egg of stool) while the rest (5, 23.8%) had infections of moderate intensity (100-399 egg). The mean ± standard error intensity of *S. mansoni* was 71.7 ± 12.88 egg of stool (range 12-240 egg). All STH infections were of light intensity as shown in Table 2.

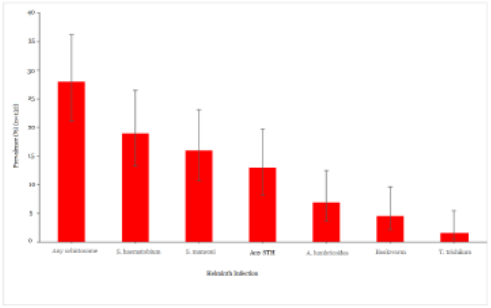

Figure 1: Prevalence of infection with helminths in preschool age children. The error bars indicate 95% confidence intervals.

Table 2: Intensity of helminthic infestations.

Parasite	Intensity	Number	%
Hookworm (n=6)	Light (1-1,999 egg)	6	100
	Moderate (2,000-3,999 egg)	0	0
	Heavy (≥ 4,000 egg)	0	0
A. lumbricoides (n=9)	Light (1-4,999 egg)	9	100
	Moderate (5,000-49,999 egg)	0	0
	Heavy (≥ 50,000 egg)	0	0
T. trichiura (n=2)	Light (1-999 egg)	2	100
	Moderate (1,000-9,999 egg)	0	0
	Heavy (≥ 10,000 egg)	0	0
S. mansoni (n=21)	Light (1-99 egg)	16	76.2
	Moderate (100-399 egg)	5	23.8
	Heavy (≥ 400 egg)	0	0
S. haematobium (n=25)	Light (1-49 eggs/10 ml urine)	21	84
	Heavy (≥ 50 eggs/10 ml urine)	4	16

Analysis of the variations of the prevalences of infections with helminths by age of the children

Investigations of the distribution of helminths infections by age of the study participants showed that a higher proportion of older children (36-59 complete months) were infected with *S. mansoni* when compared to their younger counterparts (<3 years) (28.6% vs. 12.3% respectively, p=0.039). Moreover, *S. haematobium* infections were more prevalent among the older children than among their younger equals (32.1% against 15.4% respectively, p=0.045). Children who were diagnosed with either one or both species of schistosome comprised 21.2% of the children in the younger age group and 53.6% of children in the older age category (p=0.001). The distribution of STH infestations including hookworm, *A. lumbricoides* and *T. trichiura* did not vary significantly with the age of the study participants (Table 3).

Table 3: Results of the analysis of parasitic infections and age of the study participants.

Infection	Age [n (%)]		p value
	<3 years	3- <5 years	
S. mansoni			
Positive	13 (12.5)	8 (28.6)	0.039
Negative	91 (87.5)	20 (71.4)	
S. haematobium			
Positive	16 (15.4)	9 (32.1)	0.045
Negative	88 (84.6)	19 (67.9)	
Schistosome infection			
Positive	22 (21.2)	15 (53.6)	0.001
Negative	82 (78.8)	13 (46.4)	
Any STH			
Positive	15 (14.4)	2 (7.1)	0.307
Negative	89 (85.6)	26 (92.9)	
A. lumbricoides			
Positive	7 (6.7)	2 (7.1)	0.939
Negative	97 (93.3)	26 (92.9)	
Hookworm			
Positive	3 (2.9)	3 (10.7)	0.077
Negative	101 (97.1)	25 (89.3)	
T. trichiura			
Positive	1 (1.0)	1 (3.6)	0.316
Negative	103 (99.0)	27 (96.4)	

Distribution of the infections with helminths by the sex

Significantly more males than females were positive for infections with *S. mansoni* (22.5% vs. 8.2% respectively, p=0.025), *S. haematobium* (respectively, 25.4% and 11.5%, p=0.042) and at least one species of schistosome (38.0% in males and 16.4% in females, p=0.006). Prevalences of STH infections were no different when analyzed by sex of the study participants (Table 4).

Table 4: Results of the analysis of parasitic infections and the sex of the study participants.

Parasite	Sex [n (%)]		p value
	Male	Female	
S. mansoni			
Positive	16 (22.5)	5 (8.2)	0.025
Negative	55 (77.5)	56 (91.8)	
S. haematobium			
Positive	18 (25.4)	7 (11.5)	0.042
Negative	53 (74.6)	54 (88.5)	
Schistosome infection			
Positive	27 (38.0)	10 (16.4)	0.006
Negative	44 (62.0)	51 (83.6)	
Any STH			
Positive	10 (14.1)	7 (11.5)	0.655
Negative	61 (85.9)	54 (88.5)	
A. lumbricoides			
Positive	5 (7.0)	4 (6.6)	0.912
Negative	66 (93.0)	57 (93.4)	
Hookworm			
Positive	4 (5.6)	2 (3.3)	0.517
Negative	67 (94.4)	59 (96.7)	
T. trichiura			
Positive	2 (2.8)	0 (0.0)	0.187
Negative	69 (97.2)	61 (100.0)	

Association between schistosomiasis and nutritional status of the study children

Table 5 shows the results of the effects of schistosome infections on the nutritional status of the children who participated in the current study. Stunting was significantly associated with schistosomiasis with prevalence of schistosome infections being higher in children who were stunted compared to the ones who were not stunted (52.2% against 22.9% respectively, odds ratio (OR) 3.665 (95% CI 1.443-9.309), p=0.005). Additionally, children who were underweight had approximately nine-fold higher odds of being diagnosed with schistosomiasis (OR 8.460 (95% CI 2.105-33.999), p=0.001). The prevalence of anaemia was significantly higher among those who were diagnosed with schistosome infections when compared to those tested negative with the former having about three-fold higher odds of being anaemic (57.1% vs. 14.4% respectively, OR 7.897 (95% CI: 3.383-18.438), p<0.001). Furthermore, there were significant variations in the haemoglobin concentrations between the two groups (infected and non-infected) (mean ± standard error (se): 10.6 ± 0.15 g/dl against 11.9 ± 0.10 g/dl for those who were positive and negative for schistosomiasis, respectively, p<0.001). Thinness as indicated by BMI-for-age z-scores was not significantly associated with prevalence of schistosomiasis (OR 0.696 (95% CI 0.412-0.657), p=0.412). Additionally, wasting and MUAC were not significant predictors of the schistosomiasis infection status in the study group (p=0.451 and p=0.381 respectively).

DISCUSSION

The findings from current cross sectional survey highlights a significant burden of infections with schistosome and STH among PSAC living in the study area. In this study, about one in three children was found to be infected with one or both species of schistosomes. Approximately one-tenth of the PSAC had concurrent schistosome infections while one-quarter of the PSAC had infections with *S. haematobium*. One out of every five PSAC examined was positive for infection with *S. mansoni*. Besides, STH infections were reported in more than one-tenth of the children who participated in the study. The findings adds to the growing body of evidence supporting the call for inclusion of PSAC in the schistosomiasis and soil transmitted helminthiasis control programs.

A review of literature indicates wide variations in estimates of the burden of schistosome and STH infections among PSAC. This could be explained by the differences in both environmental and host specific factors that may impact on the transmission of these infections. These may include population heterogeneity, genetics, age, poly-parasitism, temporal aspects, geographic settings, parasitological method used, personal hygiene practices, climate and altitude among others. Contrary to our findings, a study done in Ethiopia reported a higher prevalence of STH infections among PSAC (23.3%) with *A. lumbricoides* being the predominant STH species (14.9%)

followed by *T. trichiura* (6.4%) and hookworm (3.2%) [16]. The disparities in the results from the two studies could be partially attributed to the differences in the settings of the two surveys: the Ethiopian research was community based whereas the current study was undertaken in health facilities. Indeed, a hospital-based study carried out in the same country reported prevalences which are not very different from what was found in this study: infections with *A. lumbricoides* and *T. trichiura* were 10.8% (95%CI 6.6%-15.1%) and 1.4% (95% CI 0.0%-3.0%) respectively [17]. Infections with STH were detected in 26.5% PSAC in Hoima district, Uganda; hookworm infection was the most prevalent STH (18.5%) [18]. The higher prevalences could most probably be due to the differences in transmission rates and environmental conditions in the two study areas. On the other hand, the Ugandan study reported similar prevalences of infections with regard to *A. lumbricoides* (9.8%) and *T. trichiura* (0.5%) when compared to the current study [18].

The prevalence of *S. haematobium* recorded in this study (18.9% 95% CI 13.2%-26.5%) is no different compared to the 19.8% reported by a team led by Opara [19] in a research that focused on pre-school children in Nigeria. However, our estimate is slightly higher compared to the prevalence of 11.2% reported among infants in Ghana [20]. The Ghanian study recruited much younger children compared to our study (included children aged six months and below) and this may be the one of the reason for the discordance in the findings. The younger children have lesser exposure to the infections compared to the elder ones hence a lower likelihood of being infected.

Table 5: Assessment of the effect of schistosome infections on the nutritional status of children.

Nutritional status	Schistosomiasis [n (%)]		OR (95% CI)	p value
	Positive	Negative		
Weight-for-length/height z-score)				
Wasting (<-2 z-scores)	7 (35.0)	13 (65.0)	1.472 (0.536-4.039)	0.451
Normal (≥ -2 z-scores)	30 (26.8)	82 (73.2)	REF	
Length/height-for-age z-scores				
Stunting (<-2 z-scores)	12 (52.2)	11 (47.8)	3.665 (1.443-9.309)	0.005
Normal (≥ -2 z-scores)	25 (22.9)	84 (77.1)	REF	
Weight-for-age z-scores				
Underweight (<-2 z-scores)	8 (72.7)	3 (27.3)	8.460 (2.105-33.999)	0.001
Normal (≥ - 2 z-scores)	29(24.0)	92(76.0)	REF	
BMI-for-age Z scores				
Thin (<-2 z-scores)	9(23.1)	30(76.9)	0.696(0.293-1.657)	0.412
Normal (≥ - 2 z-scores)	28 (30.1)	65 (69.9)	REF	
MUAC Z scores				
Low (<-2 z-scores)	4 (40.0)	6 (60.0)	1.798 (0.477-6.776)	0.381
Normal (≥ - 2 z-scores)	33 (27.0)	89 (73.0)	REF	
Haemoglobin level				
Anaemic (<11 g/dl)	24 (57.1)	18 (42.9)	7.897 (3.383-18.438)	<0.001
Normal (≥ 11 g/dl)	13 (14.4)	77 (85.6)	REF	
Haemoglobin				
(mean ± standard error (g/dl))	10.6 ± 0.15	11.9 ± 0.10		<0.001

Our findings on hookworm prevalence (4.5%) was much higher compared to those reported in rural KwaZulu-Natal, South Africa where prevalence of hookworm was 1.6%. The South African study, however, found higher prevalence of *A. lumbricoides* (18.3%). On the other hand, the prevalence of *T. trichiura* (1.2%) in the study was not very different from what was found in the present study [21]. The prevalence of *S. mansoni* in this study (15.9%) was lower compared to that of a research done in North-Western-Tanzania where the proportion of PSAC infected with *S. mansoni* was 44.4% (95% CI 39.4%-49.4%) [22]. The differences may be due to the age of the study participants whereby the latter study enrolled PSAC of between one and six years of age while in the present research PSAC's age ranged from seven to 59 months. Research on helminth infections among PSAC conducted in Tanzania reported findings which are in concordance with those of the current study with Schistosoma spp. being the predominant helminth species (prevalence 15.8%; 95% CI 12.1-20.3%). Conversely, the Tanzanian study reported a significantly lower burden of *S. haematobium* infections among PSAC (1.0%) [23]. The difference could partly be attributed to disparities in the study settings. Unlike the present research which was done in the rural area, the Tanzanian study was done in an urban set up. The dissimilarities in the findings between the two studies could also be a reflection of the differences in the abundance of intermediate hosts of *S. haematobium* (Bulinus spp.) in the two study sites.

A research on PSAC recruited around Mbita Causeway, Western Kenya, found that 45.1% of the children were infected with *S. mansoni* (95% CI 41.7%-48.5%) [24]. The higher burden of schistosomiasis observed in this study is not surprising considering that the Causeway has been documented to be a hotspot characterized by high intensity of transmission of schistosomiasis.

Until recently when it was demolished to pave way for a bridge, the artificial pathway of the Causeway contributed to the increased numbers of *S. mansoni* host snails due to obstruction of the waterway hence elevating the risk of transmission of schistosome infections [25]. Compared to our study, the prevalence of hookworm (1.1%, 95% CI 0.4%-1.8%) and *A. lumbricoides* (1.8%, 95% CI 0.9%-2.8%) was lower in the Western Kenya study while the no difference in the burden of *T. trichiura* reported in both studies (1.1%, 95% CI 0.4%-1.8%) [24]. Individuals with mixed infections tend to experience more severe infection-related morbidities. In the current research, concomitant infections with *S.haematobium* and *S.mansoni* were detected in 6.8% of PSAC. 28.6% (22.3%-35.7%). Simultaneous infections with both forms of schistomiasis among PSAC were also reported in a study conducted in Niger [26].

Generally, heavy intensity infections with helminths (both schistosome and STH) were not common among PSAC who took part in our study. Only five PSAC (3.8%) had infections of heavy intensity and these were specifically *S. haematobium* infections. Analogous observations were made by a research conducted in Uganda which noted no heavy intensity infections with *A. lumbricoides* and *T. trichiura* among PSAC [18]. The prevalence of heavy-intensity infections with *A. lumbricoides* and *T. trichiura* was 18.2% and 11.7% respectively, in a study that involved PSAC in Philippines No heavy-intensity hookworm infections were observed in this study [27].

Research among PSAC in Mbita Causeway, Mbita, Kenya reported the following proportion of intensities of infections with *S. mansoni*: light 28.9% (95% CI 25.8%-32.0%), moderate 10.6% (95% CI 8.4%-12.7%) and heavy 5.7% (4.1%-7.3%). The infections with STH were all of light intensity [24]. The dissimilarity in these findings with those of the present survey could be ascribed to differences of contact patterns of humans to infested waters, the presence and abundance of competent intermediate host snail, availability and abundance of suitable habitats for the intermediate snail hosts, the level of freshwater contamination with stool and/or urine containing eggs with miracidium and also the variations of immunity of human hosts [28].

Chronic anaemia acquired in early in life is associated with impairments in overall physical growth, cognitive development and poor school performance, later in life [29]. Besides, severe anaemia accounts for up to one-half of the mortalities in children aged less than 5 years [30]. Our study showed that approximately one-third of the studied PSAC were diagnosed with anaemia and the burden of anaemia was higher among PSAC who tested positive for schistosome infections.

This is in agreement with a study carried out in Niger, which concluded that *S. haematobium* infections increased the risk of anaemia by 30% [31]. Similarly, a study from Tanzania, reported that haemoglobin concentration in infected children was 0.4 g/dl lower than in uninfected children [32]. The findings are also in agreement with those of a study carried out in Uganda where a significantly higher proportion of *S. mansoni* positive children were anaemic (52.3% in the infected group and 35.2% in the uninfected group, $p<0.005$) [33]. The results are consistent with the conventional knowledge that schistosomiasis is among the myriad causes of anaemia. Even though malaria and hookworm infections are also known to cause anaemia, their prevalence, in the present study, was marginal. Moreover, the intensities of infections with hookworm were low. The findings are not surprising because malaria and hookworm infections are not common in children under five years of age; rather they are more prevalent in adults and older children [34].

About one out of every five PSAC who took part in the study was stunted. Stunting was more prevalent in PSAC who had schistosome infections. In addition, approximately one-tenth of the PSAC were underweight with higher odds of being underweight being recorded among PSAC in the schistosomiasis positive group. A study among PSAC in Zimbabwe indicated higher prevalences of malnutrition in this age group; underweight (prevalence 10.1% (95% CI 8.5% to 11.9%), and stunting (prevalence 18.0% (95% CI 16.0% to 20.3%). Consistent with the present study findings the Zimbabwean study found that, on comparing infected and uninfected children, prevalence of stunting was significantly higher among PSAC who had schistosome infections (27.0%; 95% CI 19.9% to 35.6% and 17.0%; 95% CI 14.9% to 19.4% respectively, $p=0.009$) [35].

The proportion of PSAC who were stunted, underweight and exhibiting wasting/thinness were 39.5%, 22.8% and 11.4%

respectively according to a study done in Southwest Nigeria. In this study, there was no significant association between the nutritional indicators and intestinal schistosomiasis and soil transmitted helminthiasis [36]. The wide disparities in findings most probably mirrors the socioeconomic status in the study settings.

The current study is not without limitations. The history of deworming of the children who were studied was not recorded and this represents a potential confounder in the relationships that were investigated in the current study. Additionally, due to resource limitations, only one sample of stool and urine was taken from the study participants. This could have led to under-estimation of the actual burden of helminthiases attributed to intermittent variations in excretion of eggs by the parasites. Furthermore, the diagnostic method used in the study (Kato Katz technique) is not considered to be highly sensitive, particularly in low intensity infections.

CONCLUSION

A significant burden of schistosomiasis and STH among children aged less than five years was observed in the study area. The study demonstrates unequivocally that the PSAC in this area need to be prioritized for interventions including mass treatment. For example, in line with WHO recommendations, since the egg patent prevalence of schistosomiasis in this age group is within the WHO-defined range of more than 10% but not exceeding 50%, then biennial treatment with praziquantel should be conducted [2]. With the WHO's ambitious goal of reaching 75% coverage of preventive chemotherapy targeting major helminthiases among PSAC [37], the findings from this study emphasizes the need for urgent planning and implementation of specific interventions to prevent further morbidity and to improve health of children. Our data support the call for institutionalized MDA in lieu of school-based approaches only. This will ensure that deserving PSAC are reached by pertinent interventions via alternative delivery platforms such as through the Integrated Management of Childhood Illnesses and through ECDEC.

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Appendix X: WHO Child Growth Standard

ANTHROPOMETRY: CHILDREN UNDER 5

ANTHROPOMETRY is the measurement of the human body. Anthropometric measures are used to assess the nutritional status of individuals and population groups, and as eligibility criteria for nutrition support programs. Common anthropometric measures are height, weight, and mid-upper arm circumference (**MUAC**).

Some measurements are presented as indices, including height-for-age (**HFA**), weight-for-age (**WFA**), weight-for-height (**WFH**), **MUAC-for-age**, and body mass index (**BMI**)-**for-age**. Each index is recorded as a z-score* that describes how far and in what direction an individual's anthropometric measurement deviates from the median in the 2006 WHO Child Growth Standards for his or her sex. MUAC measurements are compared to recommended cutoffs that apply to all children 6–59 months.

An individual's z-score or MUAC measurement can be used to classify how malnourished he or she is. A mean z-score can also be calculated to determine the nutritional status of a population group.

*A z-score is measured in standard deviations.

DEFINITION	INDEX or MEASURE	MODERATE	SEVERE
Stunting reflects chronic malnutrition			
Inadequate length or height* relative to age	HFA	< -2 and ≥ -3 z-score	< -3 z-score
Underweight reflects both chronic malnutrition and acute malnutrition			
Inadequate weight relative to age	WFA	< -2 and ≥ -3 z-score	< -3 z-score
Wasting reflects acute malnutrition			
Inadequate weight relative to length or height*	WFH	< -2 and ≥ -3 z-score	< -3 z-score
Inadequate muscle tissue and fat stores in the body	MUAC (6–59 months)	< 125 mm and ≥ 115 mm	< 115 mm
	MUAC-for-age (3–59 months)	< -2 and ≥ -3 z-score	< -3 z-score
Bilateral Pitting Edema reflects severe acute malnutrition			
An accumulation of fluid that starts in both feet and that can progress to other parts of the body		Any bilateral pitting edema indicates severe acute malnutrition.	
Overnutrition		overweight	obese
Excessive fat accumulation that presents a risk to health	WFH BMI-for-age	> +2 and ≤ +3 z-score	> +3 z-score

* Children under 2 years are measured lying down (length) and children 2–5 years are measured standing up (height).