2018-12

Epidemiology of intestinal schistosomiasis and efficacy of single versus repeated dose praziquantel treatments among schoolchildren in Rorya district, Northwestern Tanzania

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NM-AIST

https://doi.org/10.58694/20.500.12479/292

EPIDEMIOLOGY OF INTESTINAL SCHISTOSOMIASIS AND EFFICACY OF SINGLE VERSUS REPEATED DOSE PRAZIQUANTEL TREATMENTS AMONG SCHOOLCHILDREN IN RORYA DISTRICT, NORTHWESTERN TANZANIA

David Zadock Munisi

A Dissertation Submitted in Partial Fulfilment of the Requirements for the Degree of Doctor of Philosophy in Life Sciences of the Nelson Mandela African Institution of Science and Technology

Arusha, Tanzania

December, 2018

ABSTRACT

In Schistosoma mansoni endemic areas, administering repeated treatments may increase praziquantel cure rate (CR) and egg reduction rate (ERR), thereby improving morbidity reduction and hastening achievement of transmission control in these areas.

This was a longitudinal study which investigated the efficacy of single versus repeated praziquantel treatments of S.mansoni infections and its impact on undernutrition and anaemia. Stool samples were collected from 513 schoolchildren and examined for S.mansoni infections using the Kato-Katz method. Questionnaires were used to collect socio-demographic data, risk factors, knowledge, attitude and practices on schistosomiasis. Nutritional status was determined by anthropometry. Blood samples were collected and examined for malaria parasites and haemoglobin levels using the Giemsa stain and HaemoCue methods, respectively.

The prevalence of S.mansoni, malaria, stunting, wasting and anaemia were 84.01%, 9.16%, 38.21%, 14.42% and 29.43%, respectively. The geometric mean (GM) egg per gram of stool for S.mansoni was 167.13 (95%CI: 147.19-189.79) eggs per gram of stool. Village of residence, parent's level of education, toilet use and treatment history were predictors of S.mansoni infection. A total of 431 S.mansoni infected schoolchildren were randomized to either receive a single or repeated dose 40mg/kg dose of praziquantel. At 8 weeks post baseline treatment, CR was higher among those on repeated dose (93.10%) than those on a single dose (68.68%, $p<0.001$). Likewise, ERR was higher among those on repeated dose (97.54%) than on a single dose (87.27%, $p=0.0062$). GM epg was lower among those on repeated dose (1.30 epg) than those on single dose (3.18 epg, $p=0.036$). At eight months post baseline treatment, the rate of re-infection was about 83% and 77% among those on repeated and single treatments, respectively. No significant difference was observed in the prevalence of stunting between the two treatment regimens ($p>0.05$), with significant increase in mean haemoglobin ($p<0.05$) but without significant difference between treatments ($p>0.05$). Majority (93%) of participants mentioned using lake water for domestic chores. Although toilet ownership was high (84.61%), regular toilet use was low (55.31%). To be of sustained benefit, repeated dose praziquantel treatments should be coupled with other control measures that aim at reducing the rate of re-infection and environmental contamination.

DECLARATION

I, David Zadock Munisi do hereby declare to the Senate of Nelson Mandela African Institution of Science and Technology that this dissertation is my own original work and that it has neither been submitted nor being concurrently submitted for degree award at any other institution.

David Zadock Munisi_____ 01.12.2018

Name and signature of candidate **Date**

The above declaration is confirmed

Prof. Joram Buza_____ 05.12.2018

Name and signature of supervisor **Date**

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CERTIFICATION

The undersigned certify that they have read and hereby recommend for examination of a dissertation entitled *"Epidemiology of intestinal Schistosomiasis and Efficacy of Single Versus Repeated Dose Praziquantel Treatments Among Primary Schoolchildren in Rorya District, Northwestern Tanzania."*, in fulfilment of the requirements for the Degree of Doctor of Philosophy in Life Sciences (LiSE) at Nelson Mandela African Institution of Science and Technology (NM-AIST).

05.12.2018

Prof. Joram Buza **Date**

01/12/2018

Dr. Safari M. Kinung'hi **Date**

ACKNOWLEDGEMENT

First, I am extremely grateful to the Almighty God for constantly laying his hand on me over the entire period of my life and throughout the course of this research work.

I would also like to express my sincere gratitude to my supervisors Prof. Joram M. Buza, Safari Kinung'hi and Dr. Emmanuel Mpolya for their tireless support over the entire duration of my PhD study. A special note of appreciation goes to Dr. Kinung'hi whose invaluable serenity, motivation, sustained technical and material support during the entire fieldwork made this research work a success.

I am further grateful to the Government of Tanzania for granting me with a scholarship through the Nelson Mandela African Institute of Science and Technology to undertake this study.

My sincere appreciation to the National Institute for Medical Research Mwanza Research Centre for providing me with an opportunity to do laboratory analysis in their laboratory.

I am also extremely grateful to my lovely wife Kunegunda A. Sanga for her consistent support and encouragement during the entire period of my study. What I can say is that, this journey has not been an easy one, both academically and personally. I sincerely thank my wife Kunegunda for persistently staying by my side, even when I was petulant and stressed. Truly without her unfailing support, reaching this far, would have been close to impossible. In addition to that, I thank my children Sasha, Maximillian and Xaviera for being understanding and patient during the entire period of my studies.

Moreover, Iam overly grateful to my parents, Mr. Zadock T. Munisi and Mrs. Nancy Munisi whom to a great extent played a great role on moulding me to be the kind of a person I am today. Indeed, I can't find enough words in the world to describe how thankful I am to them. I further, thank my lovely siblings; Arnold, Glorydiana and Caroline. I feel blessed to have siblings, especially these three. They are the people that have always been there with me no matter the situation is. Their continued moral support has had a significant contribution towards completion of my studies.

DEDICATION

This work is dedicated to my parents Mr and Mrs. Zadock .T. Munisi, my wife Kunegunda A. Sanga and my children; Sasha, Maximillian and Xaviera. This work is also dedicated to my siblings; Arnold, Glorydiana and Caroline.

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LIST OF ABBREVIATIONS

BMI	Body Mass Index
BMIAZ	Body Mass Index-for-Age-Z-Score
CI	Confidence Interval
CR	Cure Rate
DALYs	Disability € Adjusted€ Life € Years
DOT	Directly Observed Therapy
EPG	Eggs per gram of faeces
GM	Geometric mean
HAZ	Height-for-Age-Z-Score
MDA	Mass Drug Administration
MRCC	Medical Research Coordination Committee
NIMR	National Institute for Medical Research
NTD	Neglected Tropical Diseases
PMC	Praziquantel Mass Chemotherapy
PZQ	Praziquantel
TDHS	Tanzania Demographic and Health Survey
TDS	Tanzania Development Support
UN	United Nations
WAZ	Weight-for-Age-Z-Score

CHAPTER ONE

1.0 General Introduction

1.1 Background Information

Schistosomiasis is a chronic and debilitating disease caused by digenetic trematode of the genus Schistosoma (Senghor et al., 2014). Humans are usually infected by five species of schistosomes, namely Schistosoma mansoni, Schistosoma haematobium, Schisosoma japonicum, Schistosoma mekongi, and Schistosoma intercalatum (Adenowo et al., 2015). Three endemic species namely Schistosoma mansoni, S.haematobium and S.intercalatum are responsible for causing Schistosomiasis in Africa, of which the most important ones are S.mansoni and S.haematobium that causes intestinal and urinary schistosomiasis, respectively (Harrison, 2005; van der Werf et al., 2003; Vennervald et al., 2004). In Sub-Saharan Africa (SSA) two major forms of Schistosomiasis occur, that is urogenital and intestinal schistosomiasis, caused by Schistosoma haematobium and S.mansoni, respectively (Poole et al., 2014). The parasite is transmitted to humans through specific fresh water snails that serves as intermediate hosts for the parasite (Colley et al., 2014). The disease is responsible for causing considerable morbidity and mortality in endemic rural communities, where it also inflicts up to 4.5 million disability-adjusted life-years (DALYs) according to the World Health Organization (WHO) estimates (King et al., 2010; WHO, 2002), and in the world the disease is the second most prevalent tropical disease next to malaria (Makunnen et al., 2013). Globally more than 700 million people are at risk of infection in 76 countries and about 207 million people are infected with the parasite of whom more than 50% suffer from related morbidity (Gryseels et al., 2006; Molyneux et al., 2005; Muhumuza et al., 2013; Steinmann et al., 2006), and more than 90% of the infected people are inhabitants of Africa south of Sahara, and the United Republic of Tanzania is the second country to Nigeria for having the highest burden of Schistosomiasis in the region (Mazigo et al., 2012; Rollinson et al., 2012; van der Werf et al., 2003).

The life cycle of the Schistosomes begins with the excretion of eggs by adult female parasite in its predilection site in the veins of the human host (Estop et al., 2008). The eggs pass from the lumen of blood vessels into adjacent tissues, and may then pass through the intestinal or bladder mucosa and are shed in the feces (in the case of S. mansoni and S. japonicum) or urine (in the case of S.haematobium) or are retained in host tissues where they induce inflammation

and then die (Colley et al., 2014; Ross et al., 2002). Whether they are excreted or trapped in tissues, schistosoma eggs remain viable for only about 2 weeks after which time they die (Colley et al., 2014). The eggs that reach freshwater will hatch, releasing miracidia that, in turn, infect specific freshwater snails. S. mansoni infects biomphalaria species, S. haematobium infects bulinus species, and S. japonicum infects oncomelania species (Ekpo et al., 2008; Ross et al., 2002). In the snail, the parasite undergoes asexual replication through mother and daughter sporocyst stages, eventually shedding tens of thousands of cercariae (the form infectious to human beings) into the water 4 weeks after snail infection (Colley et al., 2014). In 1-3 days the released non-feeding cercariae move around in water where they actively seek and must penetrate the skin of humans, or else they will die after depleting their glycogen store. In human they develop through Schistosomula after shedding their bifurcated tail, into egg laying adults which migrate to the portal venous system, where they mature and unite. Pairs of worms then migrate to the superior mesenteric veins (in the case of S. mansoni), the inferior mesenteric and superior hemorrhoidal veins (in the case of S. japonicum), or the vesical plexus and veins draining the ureters (in the case of S. haematobium), a process that requires 5-7 weeks and egg laying continues for the life of the worm, usually three to five years, the eggs finds their way into the lumen of large intestine or urinary bladder and are passed out together with feces or urine (Colley et al., 2014; Ekpo et al., 2008; Ross et al., 2002).

Both, intestinal and urinary schistosomiasis are major public health problems in Tanzania with varying levels of endemicity (Mazigo et al., 2012). In 2012 it was reported that, of the estimated population of around 43.5 million people, nearly 23.2 million were infected with schistosomiasis forming a country prevalence of about 51.5% making the country rank second to Nigeria in terms of disease burden in Africa (Mazigo et al., 2012; Pollinson et al., 2012; van der Werf et al., 2003). In particular, Schistosoma mansoni in the country is extensively distributed in the south eastern and south western sides of Lake Victoria and its islands (Mazigo et al., 2012; McCullough, 1972). In these areas it has been reported to significantly affect people, mostly schoolchildren contributing significantly to their morbidities and mortalities (Kinung'hi et al., 2015; Mazigo et al., 2015; Munisi et al., 2016b). In children Intestinal Schistosomiasis presents with non-specific signs and symptoms, progressing over time from subtle manifestations such as anemia, to more severe, debilitating, and irreversible conditions such as growth stunting, impaired cognitive

development, increased susceptibility to infection, decreased quality of life, exercise intolerance, infertility, portal hypertension and liver failure (Samuels et al., 2012).

The disease schistosomiasis has been controlled using snail control, chemotherapy, health education, and improved sanitation (Mekonnen et al., 2013). In 2001 the World Health Assembly (WHA) put forth resolution 54.19, which called upon member states to regularly treat at least 75% and up to 100% of all school aged children at risk of Schistosomiasis in order to control morbidity associated with the disease (WHO, 2002). Based on that, from 2006 the World Health Organization (WHO) started promoting a strategy phrased "preventive chemotherapy…", which entails regular administration of anthelminthic drugs to populations at risk (Garba et al., 2013), therefore reducing the occurrence, extent, severity and long-term consequences of morbidity, and in certain epidemiological conditions contributes to sustained reduction in transmission of the disease (WHO, 2006). Treatment is implemented at periodic intervals as part of either school or community-based campaigns, referred to as mass drug administration (MDA) (Olamiju et al., 2013).

Praziquantel chemotherapy has been the mainstay for schistosomiasis control in many endemic countries with the target of controlling morbidity associated with the disease and in certain epidemiological settings, contribute to sustained reduction in transmission of the disease (Mekonnen et al., 2013; Savioli et al., 2009; WHO, 2002, 2006). The drug has been shown to have good efficacy in killing both mature worms and eggs. However, the use of a single dose 40 mg/kg has limitations as PZQ does not kill immature worms present in the body at the time of treatment (Doenhoff et al., 2008; Sabah et al., 1986). When praziquantel is used in the first dose will kill the adult stages only, and in endemic areas chances of having developing immature stages are quite higher and these ones are not going to be killed by the first dose, instead as they mature they are likely to be exposed to sub lethal doses of praziquantel therefore increasing chances of developing resistance.

This restricted activity to adult worms and eggs may contribute to reduced efficacy of Praziquantel, and also contribute to raising population of adult parasites that have once been exposed to the drug, and possibly contribute to emergency of Praziquantel resistance (Sabah et al., 1986). This speculation is supported by studies elsewhere which have reported reduced sensitivity of Schistosoma mansoni to Praziquantel and a failure of complete cure in a S.mansoni infection with a standard dose (Doenhoff et al., 2009; Garba et al., 2013; Obonyo

et al., 2010; Wolfe 2003). In Tanzania, a study done in Mara region showed that even a single Praziquantel treatment could produce a genetic bottleneck with reductions in a range of measures of genetic diversity of *S. mansoni*, reduction in genetic diversity may be an initial sign of emerging resistance or tolerance to the drug (Norton et al., 2010). Because of this and the fact that there is no real alternative drug against schistosomiasis which is currently available, investigating alternative treatment strategies that may help to prolong the usefulness of the drug such as administering multiple doses is highly important (Doenhoff et al., 2009; Utzinger et al., 2011; Webster et al., 2013). In addition to that, administering more than one treatment may increase cure rate, thereby significantly hasten efforts to achieve transmission control by 2030 as stated in the sustainable development goals for neglected tropical diseases (Colley et al., 2014; UN). Besides other morbidities, intestinal parasitic infections are known to affect both the growth of children and their haemoglobin levels (Musgrove, 1993). It has further been reported that, school age children is the group that is mostly affected by intestinal parasites and also suffers the greatest morbidity attributable to these parasites (Andrade et al., 2001; Saathoff et al., 2004). Therefore this study intended to investigate the efficacy of single and repeated dose Praziquantel treatment on *S. mansoni* infection and its comparative implication on the burden of undernutrition and anemia among primary schoolchildren living in an endemic area in Rorya district, Northwestern Tanzania.

1.2 Statement of the Problem and Justification

Praziquantel has been shown to have good efficacy in killing both mature worms and eggs. However, the drug has been shown not to be effective in killing immature worms present in the body at the time of treatment (Doenhoff et al., 2008; Sabah et al., 1986). This restricted activity to adult worms and eggs may contribute to reduced efficacy of Praziquantel, and also contribute to raising population of adult parasites that have once been exposed to the drug during the time when they were less sensitive, and possibly contribute to emergency of parasite resistance or tolerance to the drug (Sabah et al., 1986). Intensified Schistosomiasis treatment with Praziquantel in mass treatment campaigns escalates the selection pressure to the Schistosome population posing a greater threat of developing resistance to the drug which is the most effective against the parasite (Doenhoff et al., 2008; Obonyo et al., 2010). This large scale administration of praziquantel without any backup drugs is of a considerable concern, should resistance to praziquantel emerge (Doenhoff et al., 2008; Obonyo et al., 2010; Sacko et al., 2009; Silva et al., 2005). Some reports have already shown reduced

sensitivity of *Schistosoma mansoni* to praziquantel and sometimes failure of complete cure in a *S.mansoni* infection with a standard dose (Doenhoff et al., 2008; Garba et al., 2013; Obonyo et al., 2010; Wolfe 2003). Morbidity due to schistosomiasis has largely been associated with the intensity of infection and preventive mass chemotherapy has been used to reduce intensity of infection and hence lower prevalence of morbidity due to the disease (Malenganisho et al., 2008; Mekonnen et al., 2013; Saviolie et al., 2009; WHO 2002, 2006). However persistent schistosome light and repeated infections has increasingly been found to be of importance in sustaining morbidities due to the parasite (Samuels et al., 2012) and complete cure and preventing re-infections may avert these subtle morbidities emanating from light infections. Therefore, administering a second treatment 4 weeks after the first treatment may increase cure rate and egg reduction rate, consequently delaying the development of parasite tolerance or resistance to the drug and also reduce environmental contamination thus hasten the success of efforts to achieve transmission control by 2030 as stated in the sustainable development goals for all neglected tropical diseases (Colley et al., 2014; United Nations, 2015). Since no real alternative drug against Schistosomiasis is currently available, there is a need to carefully investigate alternative treatment strategies as a means to prolong the usefulness of the drug (Doenhoff et al., 2009; Utzinger et al., 2011; Webster et al., 2013). This study is going to determine the efficacy of single vs repeated doses of Praziquantel treatments, this information is important for the design of appropriate treatment regimens that will improve cure rates and egg reduction rate, and accelerate efforts to achieve transmission control as stated in the strategic development goals.

1.3 Study Objectives

1.3.1 Broad Objective

To describe the epidemiology of intestinal schistosomiasis and assess the efficacy of single versus repeated dose Praziquantel treatment and its implication on the burden of anemia and undernutrition among primary schoolchildren in Rorya district, North-Western Tanzania.

1.3.2 Specific Objectives

(i) To determine the prevalence, intensity and risk factors for *Schistosoma mansoni* infection among schoolchildren in the study area.

(ii) To assess the contribution of intestinal schistosomiasis on the burden of anaemia and under nutrition among schoolchildren in the study area

(iii) To determine the efficacy of single vs. repeated dose Praziquantel treatments against *Schistosoma mansoni* infections and its implication on the burden of anemia and undernutrition among primary schoolchildren in the study area

(iv) To determine schoolchildren's knowledge, attitude and practices on schistosomiasis in the study area

1.4 Research Questions

(i) What is the level of *Schistosoma mansoni* infections and their intensities among primary schoolchildren in the study village?

(ii) What is the contribution of Schistosomiasis on the burden of anemia and under nutrition among schoolchildren in the study area?

(iii) What is the efficacy of single vs. repeated Praziquantel treatments against *Schistosoma mansoni* infections among primary schoolchildren in the study area?

(iv) What is the level of knowledge, attitude and practices on intestinal schistosomiasis among primary schoolchildren in the study area?

CHAPTER TWO

Intestinal Schistosomiasis among Primary Schoolchildren in Two on Shore Communities in Rorya District, North-Western Tanzania: Prevalence, Intensity of Infection and Associated Risk Factors[1]

Abstract

In Tanzania *Schistosoma mansoni* is of great public health importance. Understanding the prevalence and infection intensity is important for targeted, evidence-based control strategies. This study aimed at studying the prevalence, intensity and risk factors of *S. mansoni* among schoolchildren in the study area.

A cross-sectional study was conducted in Busanga and Kibuyi villages. Sampled 512 schoolchildren provided stool specimen which were examined using Kato-Katz method. Pretested questionnaire was used to collect socio-demographic data and associated risk factors.

The prevalence of *S. mansoni* infection was 84.01%, with geometric mean intensity of 167.13 (95% CI: 147.19–189.79) eggs per gram of stool (epg). Other parasites detected were, *Ascaris lumbricoides* (1.4%) and hookworms (1.4%). The geometric mean infection intensity in Busanga and Kibuyi were, 203.79 (95% CI: 169.67–244.56) and 135.98 (95% CI: 114.38–161.73) epg respectively. Light, moderate and heavy infection intensities were 34.11%, 39.91% and 25.99% respectively. Village of residence, parent's level of education, toilet use and treatment history were predictors for infection.

The high prevalence and infection intensity in this study were associated with village, parent's level of education, inconsistent toilet use and treatment history. To control the disease among at risk groups, these factors need to be considered in designing integrated schistosomiasis control interventions.

Key words: *Schistosoma mansoni*, Lake Victoria, Mara region.

[1] Journal of Parasitology Research, September 2016, 1859737

2.1 Background

Schistosomiasis is a chronic and debilitating disease caused by a waterborne digenetic trematode of the genus Schistosoma (Sanghor et al., 2014). The disease is one of the most widespread parasitic infections in tropical and subtropical countries where it ranks second to malaria in terms of its socio-economic and public health significance (Jordan, 2000).

In Sub-saharan Africa (SSA) two Schistosome species are the main cause of schistosomiasis. These are S.mansoni and S.haematobium that cause intestinal and urinary schistosomiasis, respectively. The region harbours 93% of the world's 207 million estimated cases of schistosomiasis (Ross et al., 2002; van der Werf et al., 2003). The disease causes high morbidity and considerable mortality in many endemic areas where children tends to be mostly affected (King, 2010).

Schistosomiasis owes its clinical significance from its tendency to slowly damage host organs due to granuloma formation around eggs trapped in tissues, resulting into development of chronic inflammation and fibrosis in the liver and spleen causing hepatosplenomegaly that leads to severe portal hypertension, ascites, gastroesophageal varices, gastrointestinal bleeding, cancer and death (Harrison 2005; Vennervald et al., 2004). Despite the serious health impact resulting from these infections and their predominance in areas of poverty, their geographical distribution especially in rural areas of SSA remains incompletely studied (Hotez and Kamath, 2009; McCreesh and Booth, 2013).

In Tanzania, both S.mansoni and S.haematobium are highly endemic, and the country ranks second next to Nigeria in terms of disease burden in Africa (Mazigo et al., 2012; Ross et al., 2002; Steinmann et al., 2006). Intestinal schistosomiasis is of great public health significance along the shores of Lake Victoria (Mazigo et al., 2012). High exposure to infested water bodies makes schoolchildren in this region the most affected group hereby besides its clinical implication, it contributes to their growth retardation and poor school performance (Assefa et al., 2013). A number of factors that range from political, demographic, social, economic, environmental, climatic and cultural trends are known to determine the transmission of schistosomiasis, directly or indirectly (Beniston, 2002; Cox, 1993). High infection prevalence have been correlated to coming into contact with infested water bodies in various ways (Kabatereine et al., 2004).

Underlying any sound and effective control strategy for Schistosomiasis is a thorough understanding of the prevalence, intensity and local transmission pattern of the parasite, of which in Mara region, many parts have not been well studied making epidemiological data sparse and very incomplete (Mugono et al., 2014). Although several studies have been conducted on the prevalence of *S. mansoni* and their risk factors in Tanzania, there is still a lack of epidemiological information in some localities of North-western Tanzania. This study therefore aimed at studying the prevalence and intensity of *S. mansoni* and its associated risk factors among primary school children in the study area. This information is important for strengthening the understanding of local schistosomiasis transmission patterns which in turn will be used in developing sound, targeted and evidence based control interventions.

2.2 Methods

2.2.1 Study Area

This study was conducted in Rorya district, Mara region North-western Tanzania. The district is bordered by Tarime district to the east, Butiama district to the south, Lake Victoria to the west, and the Republic of Kenya to the north (Webber and Chirangi, 2014). The majority of inhabitants of Rorya district are from the Luo tribe. Other ethnic groups are Kurya, Kine, Simbiti, Sweta and Suba. The district is situated in the North-western part of Tanzania and lies between latitudes 1°06' and 1°45" south of the Equator and longitudes 33° 30' and 35° 0" east of Greenwich meridian. Rorya district has two agro-ecological zones namely the midlands and the low lands with temperature varying from 14°c to 30°c. The annual rainfall ranges from 700mm to 1200mm. The district has a total area of 9,345 square kilometers. In the study district five most commonly reported causes of morbidity and mortality are Malaria, Acute Respiratory Infections/Upper Respiratory Tract Infections, Diarrhoea, Intestinal worms and Pneumonia (TDS, 2013).

2.2.2 Study Design

This was a cross-sectional study which was part of a longitudinal randomized intervention trial. This cross-sectional baseline survey assessed the prevalence and intensity of *Schistosoma mansoni* infection among primary school children in the selected schools.

2.2.3 Study Population, Inclusion and Exclusion Criteria

The study population consisted of primary school children aged 6-16 years attending pre-grade one to grade six in Busanga and Kibuyi primary schools in two villages of Busanga and Kibuyi, respectively. All schoolchildren between 6-16 years of age who agreed to participate in the study and whose parents gave a written informed consent were eligible for the study. Schoolchildren who had a history of being clinically ill and used anti-schistosome drugs within a period of six months before the study and those whose parents refused to sign written informed consent forms and for whom evidence of being sick during the time of recruitment was apparent, were excluded from the study.

2.2.4 Sample Size Determination and Sampling Procedures

This study was part of a longitudinal interventional study, which aimed at comparing cure rates for two different treatment regimens. Therefore the sample size was calculated using a formula used for comparing two rates (Hsieh, 1994). In the calculations we used cure rates reported from a study of communities living along the shores of Lake Albert in Uganda, which reported cure rates of 41.9% and 69.1% for single dose and two doses treatment regimen, respectively (Kabatereine et al., 2003). We set the level of significance at 95% and power of 90%. Adding 30% annual loss to follow up, a total sample size of 257 per treatment group was required, however we managed to recruit a total of 513 study participants for the entire study.

Conveniently two schools along the Lake Victoria shores were selected from two villages namely Busanga and Kibuyi. A total of 246 and 267 schoolchildren were recruited from Busanga and Kibuyi primary schools, respectively. We sampled children from pre-grade one to grade six. Children in grade seven were excluded because they were about to do their final national examinations and they would not be around during the follow up surveys. The number of schoolchildren selected from each class was determined by the probability proportional to number of children in the class. An attempt was made to sample equal numbers of boys and girls from each class. The total number of schoolchildren selected from each class was determined by the probability proportional to the number of children in the class. Then half of this number was to be boys and half girls. Systematic random sampling method was used to obtain study participants for each sex in each class. The schoolchildren in each class were requested to stand in two lines, one for boys and the other

one for girls and they were counted. The sampling interval was obtained by dividing the total number of each sex in the class with the number of each sex to be investigated from that class (N/n). After obtaining a starting point from a table of random numbers, children were sampled according to the sampling interval. The same interval was kept until the required number of children for each sex in each class was obtained.

Figure 1: The study sites in Rorya district, Tanzania

2.2.5 Data Collection

(i) Assessment of Socio-Demographic Information and Risk Factors

A pre-tested Kiswahili translated semi-structured questionnaire was used to gather demographic information and risk factors for *S.mansoni* infection. Variables such as age, sex, socio-economic activities of parents/guardians, sanitary practices and water contact behaviour were assessed as potential risk factors for the disease. The questionnaire was initially developed in English and then translated to Kiswahili and back-translated by a different person who was blinded to the original questionnaires.

(ii) Stool Sample Collection, Processing and Examination

A day before stool sample collection, the study objectives were explained to the school teachers and children. Then schoolchildren were provided with informed consent forms to take home to their parents/guardians. They were instructed to tell their parents/guardians to read and understand and then sign if they agree for their children to participate in the study. The next morning children with signed written informed consent forms were provided with labelled, small, clean, dried, and leak proof stool containers and clean wooden applicator sticks. Then, they were informed to bring a sizeable stool sample of their own. A single stool sample was collected from all study participants. Each of the specimens was checked for its label, quantity and procedure of collection. Four Kato-Katz thick smears were prepared from different parts of the single stool sample using a template of 41.7 mg (Vestergaard Frandsen, Lausanne, Switzerland), following a standard protocol (WHO, 1991, 2002). The intensity of *S.mansoni* infection was calculated based on the intensity classes set by WHO as light (1-99 epg), moderate (100-399 epg) and heavy (epg ≥ 400) (WHO, 2002).

2.3 Data Analysis

The collected data were entered into a database using EpiData version 3.1. Data analysis was done using STATA version 12.1 (Stata corp, Texas, USA). The chi-square test was used to compare proportions and to test for association between *S.mansoni* prevalence between exposure groups. Parasite counts were normalized by log transformation, averaged and then back transformed to the original scale. *S.mansoni* infection intensities were calculated as geometric mean of eggs per gram of faeces. The student's t-test and one way analysis of variance (ANOVA) was used to compare geometric mean parasite counts where two or more

than two groups were compared, respectively. Logistic regression analysis was performed to determine the independent effect of the independent variables with dependent variable by calculating the strength of the association between intestinal parasites infection and determinant factors using odds ratio (OR) and 95% confidence interval (CI). Crude and adjusted OR was estimated by bivariate and multivariate logistic regression analysis with respective 95% CIs, respectively. P-value of less or equal to 0.05 was considered as statistically significant.

2.4 Ethical Statement

The study was approved by the Medical Research Coordination Committee (MRCC) of the National Institute for Medical Research (NIMR), Tanzania (Reference No. NIMR/HQ/R.8a/Vol. IX/1990). The study received further approval from the District Executive Director, District Education Officer, Medical Officer of the Rorya district council. Before commencement of the study, the research team conducted meetings with the village executive officers, teachers and students of selected villages and schools, respectively. During these meetings, the objectives of the study, the study procedures to be followed, samples to be taken, study benefits and potential risks and discomforts were explained. Informed consent for all children who participated in the study was sought from parents and legal guardians by signing an informed consent form. Assent was sought from children who were also informed of their rights to refuse to participate in the study and to withdraw from the study at any time during the study. At baseline, all children were given a standard dose of praziquantel (40mg/kg) and albendazole (400mg) as a single dose after stool sample collection. Treatment with praziquantel was given after a meal, which was prepared and offered at school to minimize potential side effects. Treatment was performed under direct observation (DOT) of a qualified nurse.

2.5 Results

2.5.1 Socio-Demographic Characteristics of the Study Participants

A total of 513 schoolchildren from the two primary schools were enrolled into the study. Of these children, 49.71% (n = 255) were boys and 50.29% (n = 258) were girls. Of all the study participants 246 (47.95%) and 267 (52.05%) were from Busanga and Kibuyi primary schools, respectively. The numbers of girls and boys in Busanga primary school were 125 (50.81%)

and 121 (49.19%) respectively whereas the numbers of girls and boys in Kibuyi primary school were 133 (49.81%) and 134 (50.19%), respectively. The age of the children ranged from 6 to 16 years with the mean of 10.9 (± 2.4) years. The number of children at Busanga and Kibuyi primary schools in the age categories 6 – 9 years were 87 (56.13%) and 68 (43.87%), respectively; 10 – 12 years were 97 (46.19%) and 113 (53.81%) respectively and 13 – 16 years were 62 (41.89%) and 86 (58.11%), respectively.

2.5.2 Prevalence of S. mansoni and Other Soil-Transmitted Helminths (STH) among Primary School children at Busanga and Kibuyi Primary Schools

Overall, 84.01% (431/513) of all the study participants were infected with S. mansoni. Other parasites found on Kato-Katz technique were Hookworms 1.4% (7/513) and Ascaris lumbricoides 1.4% (7/513). All children who were positive for Ascaris lumbricoides were also positive for S. mansoni, while six of those with hookworms were also positive for S. mansoni. None had both Ascaris lumbricoides and Hookworm infections. The prevalence of Soil-transmitted helminths in this study was too low for any valid statistical analysis to be done.

2.5.3 Prevalence of S. mansoni Stratified by Demographic Characteristics

Girls had slightly higher prevalence of S. mansoni than boys but the difference was not statistically significant ($p=0.31$). However the prevalence of infection varied significantly between age groups ($p=0.004$) with those aged 10 – 12 years having the highest prevalence and those aged 6 – 9 years having the lowest prevalence. There was also a very strong association between infection prevalence and children's village, where children at Busanga village had a significantly higher prevalence of infection as compared to those at Kibuyi village ($p=0.001$). S. mansoni infection seemed to vary significantly with parents' level of education ($p=0.036$). Toilet use was also associated with S. mansoni infection, with those who reported to use a toilet at home only sometimes having a significantly higher prevalence of infection ($p=0.01$). Those who reported to visit the lake had a significantly higher prevalence of infection as compared to those who reported to not ($p=0.018$). Children who reported to have ever had a person with intestinal schistosomiasis at home had a significantly higher prevalence than those who had no history of having a person with intestinal schistosomiasis at home ($p=0.005$). Children who spent most of their time on the shoreline when at the lake,

had a significantly higher prevalence of *S. mansoni* infection as compared to those who spent most of their time when at the lake on the inner (deeper) parts of the lake ($p=0.022$)(Table 1).

Table 1: Prevalence of S.mansoni stratified by socio-demographic characteristics of study participants

Variable	No examined	Prevalence (%)	p-value
Sex (n=513)			
Male	255	210 (82.35)	
Female	258	221 (85.66)	0.31
Age (in years) (n=513)			
6 € 9	155	122 (78.71)	0.004
10 € 12	210	190 (90.48)	
13 € 16	148	119 (80.41)	
Village (n=513)			
Busanga	246	220 (89.43)	0.001
Kibuyi	267	211 (79.03)	
Parent€s level of education (n=488)			
No formal education	48	45 (93.75)	0.036
Primary education	337	290 (86.05)	
Secondary education	58	45 (77.59)	
Collage education	5	5 (100.00)	
University education	1	1 (100.00)	
Don•t know	39	28 (71.79)	
Parent is a farmer/Livestock keeper (n=488)			
Yes	221	187 (84.62)	0.90
No	267	227 (85.02)	
Parent is fishing (n=488)			
Yes	241	212 (87.97)	0.06
No	247	202 (81.78)	
Parent is doing small businesses (n=488)			
Yes	70	58 (82.86)	0.62
No	418	356 (85.17)	
Parent is employed (n=488)			
Yes	32	29 (90.63)	0.35
No	456	385 (84.43)	
Use toilet at home (n=414)			
Always	229	183 (79.91)	0.01
Only sometimes	185	165 (89.19)	
Visit the Lake (n=488)			
Yes	471	403 (85.56)	0.018
No	17	11 (64.71)	
Part of the lake (n=370)			
On the shoreline	350	307 (87.71)	0.022
On deeper part of the lake	120	95 (79.17)	
Ever had a person with intestinal Schistosomiasis in household (n=488)			
Yes	251	224 (89.24)	0.005
No	237	190 (80.17)	

p-values calculated based on Chi-square statistic

2.5.4 Intensity of *Schistosoma mansoni* Infection among Study Participants

The overall geometrical mean egg per gram of faeces (GM-epg) for individuals with *S.mansoni* infection was 167.13 (95% CI: 147.19 – 189.79). The GM-epg intensity for Busanga was 203.69 (95% CI: 169.67 – 244.56) epg and for Kibuyi was 135.98 (95% CI: 114.33 – 161.73) epg. The distribution of light, moderate and heavy intensity infection as categorized by WHO were 34.11%, 39.91% and 25.99%, respectively. Boys had slightly higher GM-epg than girls, but the difference was not statistically significant ($p>0.05$). The geometric mean egg counts per gram of stool seemed to increase across age group with those between 6 – 9 years having the lowest mean epg and those between 10 – 13 years having the highest mean epg, but the observed difference was not statistically significant ($p>0.05$). Parent's level of education was significantly associated with geometric mean epg, with children who reported their parents not to have any formal education bearing the highest mean epg than other categories ($p=0.005$) (Table 2). Children who reported that their parents are fishing had a significantly higher intensity of infection as compared to those whose parents were not involved in fishing ($p<0.001$). Again parent employment status was significantly associated with intensity of *S.mansoni* infection, with those children whose parents were not employed bearing higher intensity as compared to those whose parents were employed ($p=0.018$). Children who reported to have had a person with intestinal schistosomiasis in their household had significantly higher intensity of infection as compared to those who reported otherwise ($p<0.001$). The intensity of infection seemed to vary significantly between villages, with children at Busanga bearing higher intensity than those at Kibuyi village ($p=0.002$). Again children who reported to use the toilet at home only sometimes had a slightly higher intensity of infection as compared to those who use the toilet always, but their difference was not statistically significant. No statistical significant differencein the mean egg intensity between those who reported to visit the lake and those who reported not to visit was observed, though those who visited the lake had a slightly higher mean egg counts (Table 2).

Table 2: Intensity of Schistosoma mansoni infection by socio-demographic characteristics of study participants

Variable	Number	GM-epg	95% CI	p-value
Sex (n=431)				
Male	210	171.23	142.55- 205.67	0.716*
Female	221	163.34	136.74- 195.11	
Age (in years) (n=431)				
6 € 9	122	156.67	122.73- 198.34	0.769**
10 € 12	190	167.70	138.38- 204. 38	
13 € 16	119	177.62	141.17- 223.63	
Parent€s level of education (n=414)				
No formal education	45	295.95	164.02- 428.38	0.005**
Primary education	290	172.94	149.90- 200.33	
Secondary education	45	105.30	67.36- 164.02	
Collage/University education	6	94.66	89.98€ 99.34	
Don•t know	28	185.56	106.70- 323.76	
Parent is a farmer/Livestock keeper (n=414)				
Yes	187	162.80	136.19- 194.62	0.402*
No	227	181.93	151.13€ 219.01	
Parent is fishing (n=414				
Yes	212	228.53	192.93- 270.71	<0.001*
No	202	129.21	106.86- 156.24	
Parent is doing small businesse (n=414				
Yes	58	131.03	87.41 - 196.43	0.088*
No	356	181.05	158.10- 207.32	
My parent is employed (n=414)				
Yes	29	98.39	61.12- 158.40	0.0184*
No	385	180.54	157.90- 206.43	
Ever had a person with intestinal schistosomiasis (n=414				
Yes	224	216.41	182.64- 256.43	<0.001*
No	190	132.91	109.52- 161.30	
Use toilet at home (n=348)				
Always	183	158.85	131.33- 192.14	0.257*
Only sometimes	165	187.94	150.19- 235.18	
Visit the Lake (n=414				
Yes	403	174.91	153.43- 199.41	0.32*
No	11	116.33	46.38- 291.74	
Village (n=431)				
Busanga	220	203.70	169.67- 244.56	0.002*
Kibuyi	211	135.98	114.33- 161.73	

p-values=ttest* and ANOVA**

2.5.5 Prevalence and intensity of *S.mansoni* by history of clinical morbidity and treatment history among study participants.

S.mansoni infection was more common among children, who reported to experience stomach pain in the past two weeks as compared to those who reported not to have stomach pain, and the difference was statistically significant (p=0.002), these children also had significantly higher egg intensity than children who reported not to have stomach pain in the past two weeks. History of ever being treated for intestinal schistosomiasis was associated with significantly higher prevalence of *S.mansoni* (p<0.001) (Table 3).

Table 3: Prevalence and intensity of *S.mansoni* by clinical morbidity and treatment history

Variable	No examined	Prevalence	p-value	GM-epg (95% CI)	p-value
Had blood in stool in the past two weeks					
Yes	59	51 (86.44)	0.714	172.12 (149.69-197.91)	0.8318*
No	429	363 (84.62)		179.61 (126.44-255.22)	
Stomach pain in the past two weeks (488)					
Yes	286	255 (89.16)	0.002	129.92 (103.46-163.14)	<0.001*
No	202	159 (78.71)		206.88 (177.72-240.82)	
Had bloody diarrhoea in the past two weeks					
Yes	51	40 (78.43)	0.178	169.16 (147.42-194.10)	0.2936*
No	437	374 (85.58)		213.80 (145.78-313.56)	
Had blood in stool, stomach pain and bloody diarrhoea in the past two weeks					
Yes	8	6 (75.00)	0.436	171.68 (150.67-195.61)	0.7436*
No	479	407 (84.97)		205.55 (57.16-739.1%)	
Ever been treated for intestinal schistosomiasis					
Yes	217	197 (90.78)	<0.001	159.92 (133.77-191.20)	0.4924**
No	251	206 (82.07)		187.22 (154.25-227.23)	
I don't know	20	11 (55.00)		162.04 (73.77-355.94)	

p-values= ‡2 test , t-test* and ANOVA**

2.5.6 Determinants of *S.mansoni* Infection among Study Participants

On bivariate analysis, children's age, village of residence, parent's level of education, parent reporting fishing, using toilet only sometimes, visiting the lake, spending most of the time along the shoreline when at the lake, history of ever having a patient of intestinal schistosomiasis at home and history of ever being treated for intestinal schistosomiasis were significantly associated with higher odds of having *Schistosoma mansoni* infection ($p<0.05$).

On multivariate analysis, village of residence, parent level of education, use of toilet at home and history of ever being treated for intestinal schistosomiasis remained significant predictors of *S.mansoni* infection after adjusting for age and sex (Table 4).

Table 4: Multivariate logistic regression for factors associated with Schistosoma mansoniinfection

Independent variable	Categories	Adjusted OR (95% CI)	p-value
Age (in years)			
	6 € 9	1	
	10 € 12	2.24 (0.90-5.55)	0.083
	13 € 16	0.80 (0.33-1.92)	0.616
Sex			
	Boys	1	
	Females	0.92 (0.50-1.70)	0.783
Village			
	Kibuyi	1	
	Busanga	3.30 (1.60-6.89)	0.001
Parent€s level of education(n=488)			
	No formal education	12.52 (1.33-117.80)	0.027
	Primary education	2.76 (1.16-6.61)	0.022
	Secondary education	1	
	Collage/University education	-	-
	Don•t know	1.19 (0.34-4.16)	0.782
Parent is fishing			
	No	1	
	Yes	1.82 (0.94-3.53)	0.076
Use toilet at home(n=414)			
	Always	1	
	Only sometimes	2.15 (1.04-4.48)	0.040
Part of the lake			
	On deeper part o the lake	1	
	On the shoreline	1.45 (0.69-3.06)	0.325
Ever had a patient at home			
	No	1	
	Yes	1.31 (0.67-2.56)	0.436
Ever been treated for Intestinal schistosomiasis			
	No	1	
	Yes	2.46 (1.19-5.08)	0.015
	Don•t know	0.57 (0.13-2.55)	0.466

2.6 Discussion

Efforts have been made to document the distribution of Schistosomiasis mansoni in different parts of Tanzania (Kinung'hi et al., 2014; Lwambo et al., 1999; Mazigo et al., 2010a; Mugono et al., 2014). However there are still many areas whose prevalence and intensities of infection are yet to be documented. This study attempted to document the prevalence, intensity and factors associated with intestinal schistosomiasis among primary school children, in two communities in Rorya district that lies along the shores of Lake Victoria, North-western Tanzania.

The findings from this study have shown that Schistosomiasis due to Schistosoma mansoni is highly endemic in the study area. The prevalence of Schistosoma mansoni observed among Schoolchildren in the present study was slightly higher to what has been reported around lake victoria basin, 64.3% (Mazigo et al., 2010a) and 63.91% (Mazigo et al., 2010b) in Tanzania, Mbita island in Western Kenya (60.5%) (Odiere et al., 2012) and Sesse islands on Lake Victoria in Uganda (58.1%) (Standley et al., 2011). The high prevalence of Schistosoma mansoni in the present study is likely to be due to high dependency of the surveyed community on the lake water for different domestic and economic activities and the inadequacy of portable water supply in the area. In addition to the absence of any major control interventions which have been implemented in the study area could further explain the observed high prevalence and intensities of infection. Contrasting findings have been reported on the prevalence of schistosomiasis among boys and girls with some studies reporting boys being more affected by intestinal schistosomiasis than girls (Berhe and Solomon, 1997; Erko et al., 1991; Tilahun et al., 1999; Tsehaie et al., 1998). In these cases, higher frequency of boys coming into contact with cercaria infested water than girls was noted to be the likely cause of the observed difference. Other studies have suggested hormonal differences being the reason for the observed higher prevalence in boys than girls (Kabatereine et al., 2004) while other studies have also reported the opposite (Alemu et al., 2011; Essa et al., 2012; Worku et al., 2014). However, our study found a non significant difference in the infection prevalence and intensity between sexes, suggesting equal exposure pattern to cercarial infested water among boys and girls in the study area. This contrasting observation calls for further studies to elucidate sex predisposition to Schistosoma mansoni infections in endemic areas.

Although age was not retained on multivariate analysis in our study, it has been reported to be a significant predictor of Schistosomiasis. Haftu and colleagues reported that children in the age group 10-14 years had relatively higher infection intensities than children below 9 years of age (Haftu et al., 2014). In our study, this was shown on bivariate analysis where children in the age group of 10-12 years had the highest infection prevalence when compared to children in the age group of 6-9 years. This observation is in liaison with a common theory that in endemic areas infection may start at an early age, increasing and reaching peak at 19 years, after which it starts to decline gradually with an increase in age (Butterworth, 1998; Gryseels, 1994; Stothard et al., 2013).

This study found that the prevalence and infection intensity varied significantly by village with children at Busanga village having significantly higher prevalence and infection intensities as compared to children at Kibuyi village. The variation in infection prevalence and intensities of *S.mansoni* by geographical area has been reported elsewhere, citing variation on intensity of parasite transmission and frequency of exposure to cercariae contaminated water bodies (Sasha et al., 2015). This observation in our study is likely to be due to a relatively higher dependency of people at Busanga on lake water for domestic and economic uses as compared to Kibuyi and also to differences in the numbers and infection levels in the snails.

It has been reported that one of the primary presenting symptoms for intestinal Schistosomiasis is abdominal pain (Elbaz and Esmat, 2013) and the key determinants for morbidity progression are repeated infection, intensity and duration of infection (Cheever et al., 1997; King et al., 1986). In line with this knowledge, our study found both prevalence and infection intensities to be significantly higher among children who reported to have had stomach pain in a period two weeks preceding this study as compared to those who didn't. It was further noted that, children with a history of ever being treated for intestinal schistosomiasis had higher prevalence of infection than those who reported otherwise. This observation is likely to be due to the fact that, *S.mansoni* and other intestinal helminths infections in communities tends to be aggregately distributed, with only a few number of individuals harbouring most of the infection in the community, the kind of distribution which is due to host heterogeneities in exposure and susceptibility to infection (Chipeta et al.,

2013). These individuals are likely to be re-infected following treatment if there has not been a change in the behaviour thereby altering their exposure pattern.

The findings in this study have shown that almost 26% of the *S. mansoni* infections are heavy intensity infections, and close to 40% are of moderate intensity, this pattern of infection has been reported elsewhere (Sady et al., 2013). This observed rates of moderate and heavy intensity infections in the study area are of significant concern owing to the fact that clinical manifestations and other complications related to intestinal Schistosomiasis are highly related to the intensity of infections (Genming et al., 1997; Sukwa et al., 1986). Though not statistically significant, we found that the intensity of infection increased with age suggesting that the observed infection level is cumulative over a long time period and that there has been no major control intervention in the area.

The present study has further demonstrated that *S. mansoni* geometric mean egg count varies with parent's level of education, whereby children who reported their parents to have no formal education bearing the highest mean egg count per gram of faeces. This observation is comparable to what has been reported elsewhere that, father's level of education was significantly associated with infection with *S. mansoni*. Children from illiterate parents having higher chances of being infected as compared to children form literate parents (Ahafuts et al., 2014; Sady et al., 2013). Similar observation in this study may be due to the fact that as Schistosomiasis is a disease of poverty, it is likely that parents with no formal education are poor and therefore children under their households are living in poverty and therefore more likely to involve themselves in activities that exposes them to infections by Schistosomiasis e.g. fishing and gardening along the lake shores.

Another study elsewhere in Tanzania, reported a non significant higher *S. mansoni* geometric mean egg count per gram of faeces among children who reported their parents to be involved in fishing activities than those who reported not to (Mugono et al., 2014). In contrast our study has shown that schoolchildren who reported their parents to be involved in fishing activities had significantly higher mean egg intensity per gram of faeces as compared to those children whose parents do not fish. This observation may be because children of fishing parents are likely to start visiting lakes early in their life and have more frequent visits to the lake as compared to children of non fishing parents. Further, parent employment status was associated with intensity of infection. Children who reported their parents not to be employed

had higher mean parasite egg count per gram of stool compared to children whose parents were employed. This observation is similar to what was reported in Bamako Mali, where parent•s occupation was seen to be a significant factor associated with intestinal Schistosomiasis, with children of non-officials having higher infection prevalence than officials (Daboet al., 2015).

The present study investigated important risk factors associated with Intestinal schistosomiasis. We found a significant relationship between Schistosoma mansoni infection and village where participants lived, parent•s level of education, use of toilet at home and history of ever being treated for intestinal Schistosomiasis.

This study demonstrated that parent•s level of education was a significant predictor of Schistosomiasis, with children of parents with no any formal education having the highest infection prevalence as compared to children of parents with secondary education. This observation is similar to what was reported in western Africa, where lower education level of the head of household was a significant predictor of schistosomiasis (Matthys et al., 2007). The present study has further shown that, inconsistent use of toilet at home is a significant predictor of Schistosomiasis. This observation have been reported by other studies (Abdel-Zeid et al., 2012; WHO, 2002). On visual examination, indiscriminate defecation practice was common in the study area, as there were many faecal materials along the lake shoreline. It is apparent that children are more likely to clean themselves in the lake soon after defecation, a practice that could be responsible for the observed higher rates of infection among children who do not always use toilets at home.

Despite schistosomiasis being a water associated infection, visiting the lake was not retained in the multivariate logistic regression analysis model as a significant predictor for Intestinal Schistosomiasis although it was demonstrated to be a significant factor in bivariate analysis. Coming into contact with infested water has also been reported as a significant predictor of Schistosoma mansoni infection in other studies (Alemayehu and Tomass, 2015; Mugono et al., 2014).

2.7 Conclusion and Recommendations

The present study has demonstrated that the prevalence and intensity of infections with Schistosoma mansoni among schoolchildren in the study area is alarmingly high. We found

that the village in which the study participant lived, parent•s level of education, use of toilet at home and history of ever being treated for intestinal Schistosomiasis were significantly associated with *S.mansoni* infection. We recommend that public health interventions to control the disease should take into consideration the associated risk factors demonstrated by this study.

CHAPTER THREE

Schistosoma mansoni Infections, Undernutrition and Anaemia among Primary Schoolchildren in Two Onshore Villages in Rorya District, North-Western Tanzania[2]

Abstract

Undernutrition and anaemia remains to be a major public health problem in many developing countries, where they mostly affect children. Intestinal parasitic infections are known to affect both, growth and haemoglobin levels. Much has been reported on the impact of geohelminths on anaemia and undernutrition, leaving that of *S. mansoni* not well studied. Therefore this study intended to determine the association between *S. mansoni* infections, anaemia and undernutrition among schoolchildren in Rorya district, Northwestern Tanzania.

A cross-sectional study was carried among schoolchildren in two onshore villages namely Busanga and Kibuyi in Rorya district. Single stool specimens were collected from 513 randomly selected schoolchildren and processed for microscopic examination using Kato Katz method, nutritional status was determined by anthropometry. Blood samples were also collected and examined for malaria parasites and haemoglobin levels using the Giemsa stain and HaemoCue methods, respectively. A pretested questionnaire was used to collect socio demographic data and associated factors.

The prevalence of *Schistosoma mansoni* infection and malaria was 84.01% and 9.16% respectively. Other parasites found were *Ascaris lumbricoides* 1.36% and Hookworm 1.36%. The prevalence of stunting and wasting was 38.21% and 14.42% respectively. The prevalence of anaemia was 29.43%, whereby 0.58% had severe anaemia. *S. mansoni* was not associated with undernutrition and anaemia ($p>0.05$). The risk of stunting and wasting increased with increasing age ($p<0.001$). Anaemia was associated with age, sex and village of residence ($p<0.05$).

S. mansoni, undernutrition and anaemia are highly prevalent in the study area. The observed rates of undernutrition and anaemia were seen not to be associated with *S. mansoni* infection

[2] PLoS One, December 2016, 11(12)

suggesting possibly being a result of poor dietary nutrients. This study suggests that policy makers should consider Rorya district into national schistosomiasis control and school feeding programmes.

Key words: Undernutrition, stunting, wasting, anaemia, Schistosoma mansoni, schoolchildren, North-western Tanzania.

3.1 Introduction

Undernutrition and anaemia are still public health problems in many developing countries where they are known to mostly affect children. The two are known to affect physical and mental development and immunity thereby rendering the already vulnerable group more susceptible to infections with other commonly occurring bacterial and viral pathogens (Best et al., 2010; Grantham-McGregor and Ani, 2001; Nokes et al., 1998). It is estimated that about one-fourth of African primary schoolchildren lie under the fifth percentile of United States National Center for Health Statistics (NCHS) reference for Height-for-Age Z-score (HAZ) and nearly 40 % of pre-schoolchildren living in developing regions are anaemic (De Stefano and De Angelis, 2009; WHO, 2008).

In Tanzania, undernutrition and anaemia among schoolchildren are still major public health problems. It has been reported that up to two-third of children are anaemic (Leach and Kilama, 2009) and about 42.3% of schoolchildren are undernourished (Mwanri et al., 2014). While factors that affect growth and development in pre-school children have been well elucidated, a lot remains to be done with schoolchildren where risk factors for anaemia and under nutrition are not well understood (Mekonnen et al., 2014).

Besides other morbidities, intestinal parasitic infections are known to affect both the growth of children and their haemoglobin level (Musgrove, 1993). It has further been reported that, school age children is the group that is mostly affected by intestinal parasites and also suffers the greatest morbidity attributable to these parasites (Andrade et al., 2001; Saathoff et al., 2004). However, many studies that tried to examine the relationship between parasitic infections, undernutrition and anaemia paid much attention to geohelminths, leaving *S.mansoni* not well studied (Shubair et al., 2000; Tatala et al., 2009; Tsuyuoka et al., 1999). There have been very limited studies on the impact of Schistosome infections on anaemia and undernutrition (Chami et al., 2015; Gurarie et al., 2011; Mekonnen et al., 2014; Parraga et al., 1996; Uneke and Egede, 2009). Understanding the association between *Schistosoma mansoni* with anaemia and undernutrition will be helpful in the formulation of comprehensive interventions which aims at reducing the burden of anaemia and undernutrition in the study area and elsewhere. Therefore this study intended to determine the association between *S.mansoni* infections and anaemia and undernutrition among primary schoolchildren in the study area.

3.2 Methods

3.2.1 Study Area

This study was conducted in Rorya district, North-western Tanzania. Rorya district is one among seven districts in Mara region. The district is bordered by Tarime district to the east, Butiama district to the south, Lake Victoria to the west and the Republic of Kenya to the North (Webber and Chirangi, 2014). The majority of inhabitants of Rorya District are from the Luo tribe. Other ethnic groups are Kurya, Kine, Simbiti, Sweta and Suba. The District is situated in the North of Tanzania and lies between latitudes 1° 0' 45" south of the Equator and longitudes 33° 30' 0" and 35° 0" east of Greenwich Meridian. Rorya district has two agro-ecological zones namely the midlands and the low lands. The zones are situated between approximately attitudes 800mm and 1200mm with temperatures varying from 14°c to 30°c. The annual rainfall ranges from 700mm to 1200mm. The district has a total area of 9,345 square kilometers. The top five most commonly reported causes of morbidity and mortality are Malaria, Acute Respiratory Infections, Diarrhoea, Intestinal worms and Pneumonia (TDSR, 2013).

3.2.2 Study Design

The current study was a cross-sectional baseline survey which formed part of a longitudinal randomized intervention trial with a registration number PACTR201601001416338 registered on the Pan African Clinical Trial Registry. The longitudinal randomized intervention trial aimed to assess the efficacy of Praziquantel treatment regimen on parasitological (egg reduction rate and cure rates) and nutritional indicators. This cross-sectional baseline survey assessed the prevalence and intensity of Schistosoma mansoni infection, nutritional status and haemoglobin levels of schoolchildren. The study also assessed the socioeconomic characteristics of parents of schoolchildren in the selected villages.

3.2.3 Study Population, Inclusion and Exclusion Criteria

The study population consisted of primary schoolchildren aged 6-16 years attending primary schools in two villages of Busanga and Kibuyi in Rorya district. All schoolchildren aged 6-16 years who agreed to participate in the study and whose parents gave written informed consent were eligible for inclusion into the study. Schoolchildren who had a history of being clinically ill during the time of recruitment or had used anthelmintic drugs within a period of

6 months before the study and those whose parents refused to sign a written informed consent form were excluded from the study.

3.2.4 Sample Size Determination and Sampling Procedures

This study formed the baseline survey of a longitudinal intervention trial which aimed at comparing parasitological cure rates of two different treatment regimens of praziquantel for the treatment of intestinal schistosomiasis. Therefore the sample size was calculated using a formula used for comparison of two rates (Kirkwood, 2003). In the calculations we used the parasitological cure rates of praziquantel against intestinal schistosomiasis reported from a study of communities living along the shores of Lake Albert in Uganda, which reported cure rates of 41.9% and 69.1% for the single dose and two doses treatment regimens respectively (Kabatereine et al., 2003). We set the level of significance at 95% and power of 90%. Adding 30% annual loss to follow-up, a total sample size of 257 school children was required per treatment group. However, we were able to recruit 256 schoolchildren for the single dose treatment group and 257 for the multiple dose treatment group or a total of 513 schoolchildren for the whole study.

Conveniently two schools along the Lake Victoria shores were selected from two villages (Busanga and Kibuyi). A total of 246 and 267 schoolchildren were recruited from Busanga and Kibuyi primary schools, respectively. We sampled children from preparatory to grade six. Grade seven were excluded because they were about to do their final national examinations and they would not be around during the follow-up surveys. The number of schoolchildren selected from each grade was determined by the probability proportional to number of children in the grade. We attempted to sample equal numbers of boys and girls from each grade of which half were to be boys and half girls. Systematic random sampling method was used to obtain study participants for each sex from each grade. The schoolchildren in each grade were requested to stand in two lines, one for boys and the other one for girls and they were counted. The sampling interval was obtained by dividing the total number of each sex in the grade with the number of each sex to be investigated from that grade (N/n). After obtaining a starting point from a table of random numbers, children were sampled according to the sampling interval. The same interval was kept until the required number of children for each sex in each class was obtained.

3.2.5 Data Collection

(i) Assessment of Demographic Characteristics and Risk Factors for Infection

A pre-tested Kiswahili translated semi-structured interview questionnaires was used to gather demographic and risk factor information for infection with *S. mansoni*. Variables such as age, sex, socio-demographic characteristics, economic activities of parents/guardians, were assessed as potential risk factors for infection, anaemia and undernutrition. The questionnaire was initially developed in English and then translated to Kiswahili and back-translated by a different person who was blinded to the original questionnaire.

(ii) Stool Sample Collection, Processing and Examination

A day before stool sample collection, the study objectives were explained to the schoolteachers and children. Then schoolchildren were provided with informed consent forms to take home to their parents/guardians. They were instructed to tell their parents/guardians to read and understand the consent form then sign if they agree for their children to participate in the study. The next morning, children with signed written informed consent forms were provided with stool containers and clean wooden applicator sticks. They were requested to bring sizable stool samples of their own. A single stool sample was collected from each study participant. Four Kato-Katz thick smears were prepared from different parts of the single stool sample using a template of 41.7 mg (Vestergaard Frandsen, Lausanne, Switzerland), following a standard protocol (Katz et al., 1972; WHO, 1991, 2002). Examination of Kato smears for hookworm eggs was performed within 1 hour of slide preparation. Then the Kato smears were arranged in wooden slide boxes, packed together in large container boxes and transported using the project vehicle to the laboratory of the National Institute for Medical Research (NIMR), Mwanza centre where they were preserved at room temperature. The Kato smears were examined for *S. mansoni* eggs by two experienced laboratory technicians one week after preparation. All Kato smears prepared for each child were used to determine *S. mansoni* egg per gram of faeces (EPG) for that child. For quality assurance, a random sample of 10% of the negative and positive Kato Katz thick smears were re-examined by a third technician. Since a template delivering 41.7 mg of stool was used to prepare Kato-Katz slides, the eggs of each parasite in the slide was counted and the number of eggs was multiplied by 24 to calculate EPG for *S. mansoni* infection. The intensity

of S.mansoni infection was calculated based on the intensity classes set by WHO as light (1-99 epg), moderate (100-399 epg) and heavy (≥400 epg) (WHO, 2002).

(iii) Anthropometric Measurements

The children's heights were measured using a portable stadiometer and weight was measured using a digital weighing scale. The children's barefoot stature was recorded to the nearest 0.1 cm. Weight measures were taken to the nearest 0.1 kg without shoes and with minimum clothing. The resulting height and weight measurements were compared to a standard population of the same age group to calculate height-for-age z scores and BMI-for-age z scores. These anthropometric indices were calculated using the new World Health Organization Child Growth Standards (WHO, 2007). Any child with height-for-age z scores (HAZ) and BMI-for- age z scores (BMIAZ) below or equal to -2 standard deviation (-2SD) was classified as stunted and wasted, respectively. Children with HAZ and BMIAZ below or equal to -3 standard deviation (-3 SD) was classified as severely stunted and severely wasted, respectively. Body mass index (BMI) was used as the index of choice for the assessment of recent undernutrition because of its being recommended for use in both adults and adolescents (Bailey and Ferro-Luzzi, 1995). As part of data quality assurance, in addition to test-retest and inter-rater reliability assessments, all anthropometric measurements were taken with calibrated and validated instruments.

Age of each participant was collected from school records as reported by parents/guardians during school registration of the children. The age was reported in years in the registration, so the midpoint of the year of birth was used, and the 15th day of the month was used.

(iv) Determination of Hemoglobin Levels

Blood was collected by finger prick using disposable lancet, and a sample of blood (about 100µl) was collected and used to measures venous Haemoglobin (Hb), in a HaemoCue photometer (HemoCue, Angelholm, Sweden) (Von Schenck et al., 1986). Children with Hb levels ≥11g/dL were considered normal. Anaemia was defined as Hb levels <11g/dL while Hb levels of <7g/dL, 7.0-9.9g/dL and 10.0-10.9g/dL were classified as severe anaemia, moderate anaemic and mild anaemia, respectively (WHO, 2001).

(v) Examination for Malaria Parasites

After a finger prick and assessment for Hb, a thick blood smear was prepared for malaria parasites examination using the Giemsa stain method (Cheesbrough, 2009). The thick blood smears were examined for malaria parasite at 100X magnification.

3.2.6 Data Analysis

The collected data were entered into a database using EpiData version 3.1. Data analysis was done using STATA version 12.1 (Stata corp, Texas, USA). Simple frequency and percentages were used in the descriptive analysis. The Chi-square test and Fisher exact test were used to compare proportions and to test for associations between prevalence of Schistosoma mansoni infection, anaemia, stunting and wasting and exposure variables as appropriate. Parasite counts were normalized by log transformation, averaged and then back transformed to the original scale. S.mansoni infection intensities were calculated as geometric mean of eggs per gram of faeces. Logistic regression analysis was performed to determine the independent effect of the independent variables with dependent variable by calculating the strength of the association between anaemia, stunting and wasting and determinant factors using odds ratio (OR) and 95% confidence intervals (CIs). Crude OR and adjusted OR were estimated by bivariate and multivariate logistic regression analysis with respective 95% CIs respectively. Multivariate logistic regression analysis was conducted by fitting a logistic regression model. All variables with a p-value <0.2 in the bivariate analysis were included in the model. A p-value of less than 0.05 was considered as statistically significant.

3.2.7 Ethical Statement

The study was approved by the Medical Research Coordination Committee (MRCC) of the National Institute for Medical Research (NIMR), Tanzania (Reference No. NIMR/HQ/R.8a/Vol. IX/1990). The study received further clearance from the District Executive Director, District Education Officer and District Medical Officer of the Rorya district council. Before commencement of the study, the research team conducted meetings with the village executive officers, teachers and pupils of selected villages and schools respectively. During these meetings, the objectives of the study, the study procedures to be followed, samples to be taken, study benefits and potential risks and discomforts were explained. Informed consent for all children who participated in the study was sought from

parents and legal guardians by signing an informed consent form. Assent was sought from children who were also informed of their right to refuse to participate in the study and to withdraw from the study at any time during the study. At baseline, all children were given a standard dose of praziquantel (40mg/kg) and albendazole (400mg) as a single dose on separate days. Treatment with praziquantel was given after a meal which was prepared and offered at school to minimize potential side effects. Treatment was performed immediately after baseline data collection and was done under direct observation (DOT) by a qualified nurse.

3.3 Results

A total of 513 children between 6-16 years of age were recruited into the study. Out of these 255 (49.71%) were males and 258 (50.29%) were females. Most of the study participants (40.94%) belonged to the age group of 10-12. The majority of parents in the villages had only primary school education and about a half (49.39%) were fishermen (Table 5). The overall prevalence of stunting and wasting was 38.21% (196/513) and 14.42% (74/513), respectively. The overall prevalence of anaemia was 29.43% (151/513), with the prevalence of mild, moderate and severe anaemia being 19.69 %, 9.16 % and 0.58%, respectively (Table 6). The overall prevalence of *S. mansoni* infection was 84.01% (431/513). The overall prevalence of malaria was 9.16% (47/513) with more than 90% (43/47) of the malaria positive children being at Busanga primary school. The prevalence of *A. lumbricoides* and hookworm infections was 1.36% (7/513) and 1.36% (7/513), respectively. The Geometric mean egg counts per gram of faeces (epg) for *S. mansoni* was 167.13 (95% CI: 147.19 - 189.79), with the minimum and maximum eggs per gram of faeces being 6 and 8,496 epg respectively. The distribution of infection intensity was light (28.65%), moderate (53.63%) and heavy (21.83%) of the study participants.

Table 5: Socio-demographic information of schoolchildren who participated in the study by village

Characteristic	Village		Total n(%)	p-Value
	Busanga n (%)	Kibuyi n (%)		
Sex (n=513)				
Male	121 (49.19)	134 (50.19)	255 (49.71)	0.821*
Female	125 (50.81)	133 (49.81)	258 (50.29)	
Age (in years) (n=513)				
6 € 9	87 (35.37)	68 (25.47)	155 (30.21)	0.037*
10 € 12	97 (39.43)	113 (42.32)	210 (40.94)	
13 € 16	62 (25.20)	86 (32.21)	148 (28.85)	
Parent is a farmer (n=488)				
No	139 (58.40)	128 (51.20)	267 (54.71)	0.110*
Yes	99 (41.60)	122 (48.80)	221 (45.29)	
Parent is doing businesses (n=488)				
No	198 (83.19)	220 (88.00)	418 (85.66)	0.130*
Yes	40 (16.81)	30 (12.00)	70 (14.34)	
Parent€s level of education (n=488)				
No formal education	25 (10.50)	23 (9.20)	48 (9.84)	0.075**
Primary education	153 (64.29)	184 (73.60)	337 (69.06)	
Secondary education	38 (15.97)	20 (8.00)	58 (11.89)	
University/Collage education	3 (1.26)	3 (1.20)	6 (1.23)	
Don•t know	19 (7.98)	20 (8.00)	39 (7.99)	
Parent is fishing (n=488)				
No	125 (52.52)	122 (48.80)	247 (50.61)	0.411*
Yes	113 (47.48)	128 (51.20)	241 (49.39)	

p-values=Chi-square statistic* and Fisher exact test**

Table 6: Prevalence of *S.mansoni* infection, malaria, anaemia and undernutrition by village (n=513)

Characteristic	Village		Total n (%)	p-Value
	Kibuyi n (%)	Busanga n(%)		
Stunting				
Normal	151 (56.55)	166 (67.48)	317 (61.79)	0.037*
Moderate stunting	91 (34.08)	61 (24.80)	152 (29.63)	
Severe stunting	25 (9.36)	19 (7.72)	44 (8.58)	
Wasting				
Normal	221 (82.77)	218 (88.62)	439 (85.58)	0.113**
Moderate wasting	35 (13.11)	24 (9.76)	59 (11.50)	
Severe wasting	11 (4.12)	4 (1.63)	15 (2.92)	
Anaemia				
Normal	154 (57.68)	208 (84.55)	362 (70.57)	<0.001**
Mild anaemia	69(25.84)	32(13.01)	101(19.69)	
Moderate anaemia	43 (16.10)	4 (1.63)	47 (9.16)	
Severe anaemia	1 (0.37)	2 (0.81)	3 (0.58)	
S.mansoni infection				
Negative	56 (20.97)	26 (10.57)	82 (15.98)	<0.001*
Positive	211 (79.03)	220 (89.43)	431 (84.01)	
Malaria infection				
Negative	263 (98.50)	203 (82.52)	466 (90.84)	<0.001**
Positive	4 (1.50)	43 (17.48)	47 (9.16)	

p-values=Chi-square statistic* and Fisher exact test**

3.3.1 The Association between *S.mansoni* Infection and Stunting

Bivariate logistic regression analysis showed that, stunting was not associated with *S.mansoni* infection ($p>0.05$). However, it was significantly associated with age of children and the village in which the children lived. Accordingly children within 1 to 12 years range had 6.6 times higher odds of being stunted as compared to children aged 60 to 69 months ($p<0.001$). Likewise, children aged 13 to 16 years had 16.25 times higher odds of being stunted as compared to children aged 60-69 years ($p<0.001$). Children at Kibuyi village had 1.59 times odds of being stunted as compared to children at Busanga Villages ($p=0.011$). Children of farmers had 1.66 times higher odds of stunting as compared to those parents were not farming ($p=0.007$). Multivariate logistic regression analysis was conducted to fit a model including all variables with a p-value ≤ 0.2 in the bivariate analysis for stunting. Therefore, age group of the study participants, village, respondent parent farming and history of having

bloody diarrhoea in the past two weeks were included in the model for analysis. Controlling for other factors, age was the best predictor of stunting among schoolchildren (Table 7).

Table 7: Multivariate logistic regression analysis for factors associated with stunting among school children at Busanga and Kibuyi villages, Rorya District, North-Western Tanzania

Risk factors	Categories	Adjusted OR (95% CI)	p-value
Sex(n=513)	Male	1	
	Female	1.09 (0.73-1.64)	0.670
Age (in years)(n=513)	6 - 9	1	
	10 - 12	5.41 (2.89-10.14)	<0.001
	13 - 16	14.09 (7.36-27.17)	<0.001
Village (n=513)	Kibuyi	1	
	Busanga	0.76 (0.50-1.16)	0.199
Malaria infection (n=513)	Negative	1	
	Positive	0.67 (0.30-1.51)	0.342
Parent is a farmer (n=488)	No	1	
	Yes	1.33 (0.89-2.01)	0.164
Had bloody diarrhoea during the past two weeks (n=488)	No	1	
	Yes	0 .77 (0.38-1.57)	0.466

3.3.2 The Association between *S.mansoni* Infection and Wasting

On bivariate logistic regression analysis, wasting was observed not to be associated with *S.mansoni* infection ($p>0.05$). However it was significantly associated with age and history of having stomach ache during the past two weeks ($p<0.05$). Controlling for other factors on multivariate logistic regression analysis, the AOR indicated that age was the best predictor of wasting among schoolchildren in the study area (Table 8).

Table 8: Multivariate logistic regression analysis of factors associated with wasting among schoolchildren at Busanga and Kibuyi Villages, Rorya District, North-Western Tanzania

Risk factors	Category	Adjusted OR(95% CI)	p-value
Sex(n=513)	Male	1	
	Female	0.94 (0.55-1.61)	0.832
Age (in years)(n=513)	6 € 9	1	
	10 € 12	2.01 (0.95-4.66)	0.068
	13 € 16	4.21 (1.94-9.17)	<0.001
Village (n=513)	Kibuyi	1	
	Busanga	0.75 (0.44-1.30)	0.312
Parent is a farmer (n=488)	No	1	
	Yes	0.57 (0 .32-1.00)	0.052
Parent is doing businesses (n=488)	No	1	
	Yes	1.52 (0.59-2.48)	0.593
Schistosoma mansoni infection (n=513)	Negative	1	
	Positive	0.59 (0 .30-1.14)	0.117
Stomach pain in the past two weeks (n=488)	No	1	
	Yes	0.66 (0 .39-1.12)	0.120

3.3.3 The Association between *S.mansoni* Infection and Anaemia

Bivariate logistic regression analysis showed that, anaemia was not associated with *S.mansoni* infection ($p>0.05$). However, it was significantly associated with sex of the children, age, village in which children lived and whether the children reported their parents doing business or not. Multivariate logistic regression analysis was conducted to fit a model including all variables with a p-value ≤ 0.2 in the bivariate analysis for anaemia. Sex, age group of the study participants, village of residence, parent doing business, parent's level of education and *S.mansoni* infection status were included in the model for analysis. Controlling for other factors, sex, age and village of residence were the best predictor of anaemia among school children in the study area (Table 9).

Table 9: Multivariate logistic regression analysis of factors associated with anaemia amongst schoolchildren at Busanga and Kibuyi Villages, Rorya District, North-Western Tanzania

Risk factors	Category	Adjusted OR(95% CI)	p-value
Sex(n=513)	Male	1	
	Female	1.87 (1.15-3.05)	0.012
Age (in years)			
	13 € 16	1	
	10 € 12	4.78 (2.35-9.73)	<0.001
	6 € 9	28.24 (12.24-65.11)	<0.001
Village (n=513)			
	Busanga	1	
	Kibuyi	8.77 (4.81-16.00)	<0.001
Malaria infection (n=513)			
	Negative	1	
	Positive	0.93 (0.36-2.38)	0.880
Parent€s level of education (n=488)			
	No formal education	0.47 (0.16-1.38)	0.170
	Primary education	0.78 (0.36-1.69)	0.536
	Secondary education	1	
	University/College education	1.78 (0.20-15.79)	0.603
	Don•t know	1.40 (0.48-4.06)	0.537
Parent is doing businesses (n=488)			
	No	1	
	Yes	0.54 (0.25-1.16)	0.113
Schistosoma mansoni infection (n=513)			
	Negative	1	
	Positive	1.09 (0.55-2.18)	0.800

3.4 Discussion

Undernutrition and anaemia have continued to be major public health problems in many developing countries (WHO, 2008). The two mainly affect school-aged children who are also the victims of parasitic infections. Studies have indicated that infections with parasites may exacerbate nutritional deficiency thereby greatly affecting their physical and intellectual development (Andrade et al., 2001; Saathoff et al., 2004). In the present study we investigated the association between *S. mansoni* infection, undernutrition and anaemia among schoolchildren in two onshore villages in Rorya district, Northwestern Tanzania.

The present study found the prevalence of stunting and wasting to be high as categorised by WHO classification of severity of malnutrition by prevalence ranges (de Onis et al., 1997). Though this study did not find any association between undernutrition and *S. mansoni* infection, the prevalence of *S. mansoni* in the study area was very high (84.01%). However both stunting and wasting were significantly associated with age, whereby older children were more stunted and wasted than younger children suggesting chronic nutritional insult other than intestinal helminth infection. However, recently there has been increased recognition of chronic intestinal protozoa infections as cause of malnutrition in children and have been proposed for consideration as neglected tropical diseases that cause significant morbidity in children (Bartelt et al., 2013; Gutiérrez et al., 2014). Therefore, besides the possibility of chronic inadequate dietary nutrients, chronic intestinal protozoa infections may account for the observed rate of malnutrition. The prevalence of stunting in this study is slightly lower compared to a prevalence of 42.3% which was reported in same district, Northern Tanzania and 42.7% reported in Mpwapwa district, Central Tanzania (Hussein and Moshiro, 2007; Munisi et al., 2014). This observed difference is likely to be due to differences in climatic conditions between our study sites which lies along the shores of Lake Victoria and the other two sites, which are semi arid and endure regular food shortages (Schmied, 1993; Tesha, 2016). Adverse climatic conditions are known to affect food security and increase the risk of infectious diseases (Thompson and Cohen, 2012). The observed prevalence of wasting in this study was slightly higher than what has been reported in Same district (11.7%), but it was lower than what has been reported in Mpwapwa (13.7%) (Hussein and Moshiro, 2007). This observed difference is likely to be due to fluctuations observed on this nutritional indicator. Wasting is an indicator of acute nutritional shortage and is therefore subject to spatial and temporal fluctuations reflecting acute nutritional insult. In addition,

study methodologies used by the two studies and socio-economic differences may account for the observed differences on the prevalence of wasting. The present study further reports a prevalence of anaemia among study participants of 29.43%. This prevalence is high and classified as a moderate public health problem according to the WHO Classification of anaemia (WHO, 2008). This observed prevalence of anaemia is lower as compared to a previously reported prevalence of 62.4% in the lake zone (Lwambo et al., 1999). This observed difference in the prevalence of anaemia could be attributed to the changing patterns in prevalence of anaemia in the region as a result of the changing pattern of prevalence and intensities of intestinal parasitic infections. This study also reports that the prevalence of hookworm and *Ascaris lumbricoides* that has been very closely linked to anaemia is very low.

Our study found that stunting was not associated with *S. mansoni* infection, a finding which has also been reported in Ethiopia (Mekonnen et al., 2014). This observation suggests that *S. mansoni* infection is not an important factor in the aetiology of stunting in this area. The present study also found that age was a significant predictor of both stunting and wasting, with older children having highest chance of being stunted or wasted as compared to the youngest. It has been reported that with maturity, children's household socio-economic characteristics may act in conjunction with behavioural and biological variables as important risk factors for nutritional status (Ricci and Becker, 1996). In addition, older children tend to be more active and lose a greater amount of energy while playing. The excess energy loss in combination with inadequate dietary nutrients could make them undernourished (Degarege et al., 2015a). Wasting seemed to be more common among children who reported their parents not to be involved in farming which is likely to be due to the fact that households with farming parents are more likely to be food secure as opposed to households with non farming parents.

Sex differences were not observed for both stunting and wasting, a finding similar to what was reported by Herrador (Herrador et al., 2014) suggesting equal risk exposure for both boys and girls. However, other studies have reported that boys were more wasted and stunted than girls (Degarege et al., 2015b; Degarege et al., 2015a) citing biological factors, inequalities in resource allocation within households and socio-cultural factors to be the

likely cause of the observed difference in the risk of undernutrition between boys and girls (Degarege et al., 2015a).

Anaemia is known to be a major public health problem particularly among schoolchildren in Tanzania with the most common type being nutritional as a result of inadequate dietary intake (Schellenberg et al., 2003; TDHS, 2005). The prevalence of anaemia among school-aged children in the current study (29.43%) is of moderate public health problem according to WHO classification (WHO, 2008). This reported prevalence is higher compared to what has been reported in the nearby district of Sengerema (19.5%) but lower to what was reported in Kilosa district, Central Tanzania (43.4%) (Mazigo et al., 2010b; Mboera et al., 2015). This observed difference could be due to differences in the age of the study participants, climatic conditions of the study areas which may affect food security as already reported (Thompson and Cohen, 2012), and the difference in the prevalence of malaria which is known to greatly impact on haemoglobin levels (Kinung'hi et al., 2014). In this study, anaemia was most prevalent among schoolchildren in the village with low *S. mansoni* and malaria prevalence suggesting that anaemia among schoolchildren in the study area was most likely to be the result of dietary deficiency and probably other causes.

The study further observed that girls were more likely to be anaemic compared to boys a finding which has also been reported elsewhere (Abdel-Rasoul et al., 2015; Iannotti et al., 2015; Jani et al., 2014). This observation is likely to be due to unhealthy diet among girls and regular menstruation among older school girls (Abdel-Rasoul et al., 2015; Iannotti et al., 2015). This study noted that age is an important predictor of anaemia and being at a younger age carried a higher risk of being anaemic as compared to being older, the observation has been reported by other studies (Casabada et al., 2015; Iannotti et al., 2015). This observation suggests that children are admitted to school while already anaemic. This observation is supported by findings of other studies which shows that the prevalence of anaemia is higher among children under the age of five, with prevalence of up to 85% having been reported (Schellenberg et al., 2003; Simbaurangana et al., 2015). This observation highlights the need to target anaemia control interventions to younger children within and outside the school system with more emphasis on pre-school age children. Although many studies have reported a strong association between anaemia and malaria, in this study we did

not find any relationship between the two, most likely because of the low prevalence of malaria in our study area.

3.5 Conclusion and Recommendation

In conclusion, the current study has shown that Schistosoma mansoni, undernutrition and anaemia are highly prevalent in the study area. Although number of studies have implicated Schistosoma mansoni infection as the cause of low haemoglobin levels and undernutrition, the present study failed to demonstrate this association among schoolchildren. This observation suggests that the observed higher levels of anaemia and undernutrition are likely to be a result of inadequate intake of essential dietary nutrients. We therefore recommend for policy makers to consider school age children in Rorya district for inclusion into national schistosomiasis control and school feeding programmes.

CHAPTER FOUR

The efficacy of single versus double praziquantel treatments on *Schistosoma mansoni* infections: Its implication on undernutrition and anaemia among primary schoolchildren in two on-shore communities, north-western Tanzania[3].

Abstract

Administering more than one treatment may increase praziquantel cure rate and egg reduction rate, thereby significantly hasten efforts to achieve transmission control in endemic countries.

A total of 431 *S.mansoni* infected schoolchildren were randomized to either receive a single or repeated 40 mg/kg dose Praziquantel. Height, weight and haemoglobin were determined using a stadiometer, weighing scale and a HemoCue, respectively.

At 8 weeks, cure rate was higher among those on repeated dose (93.10%) than on a single dose (68.68%, $p<0.001$). Similarly, the egg reduction rate was higher among those on repeated dose (97.54%) than on a single dose (87.27%, $p=0.006$). Geometric mean egg intensity was lower among those on repeated (1.30 epg) than those on single dose (3.18 epg) ($p=0.036$) at 8 weeks, but not at 5 ($p>0.05$) and 8 months ($p>0.05$). No difference on re-infection rate was observed at 5 months 8 months. Moreover, no difference on the prevalence of stunting was observed between the two treatment regimens ($p>0.05$) at 8 months. There was a significant increase on the prevalence of wasting among those on repeated dose than those on a single dose praziquantel ($p<0.001$). An increase on the mean haemoglobin levels at 8 months with no difference between the two arms ($p>0.05$) was observed.

To achieve reduction of transmission intensity and ultimately disease control in highly endemic areas, repeated treatments alone may not be sufficient.

Key words: Schistosomiasis, praziquantel, Malnutrition, Anemia, Tanzania

[3] Published in Biomed Research International Journal, 28th September, 2017.

4.1 Introduction

Schistosomiasis transmitted by fresh water snails is one of the highly prevalent parasitic infections in the world, and it is estimated that more than 200 million individuals are infected at any given time, of whom over a half suffer from related morbidity and about 93% are inhabitants of sub-Saharan Africa (Gryseels et al., 2006; Molyneux et al., 2005; Steinmann et al., 2006) The disease is responsible for causing considerable morbidity and mortality in endemic rural communities inflicting up to 4.5 million disability-adjusted life-years (DALYs) (King, 2010; WHO, 2002)

Three endemic species namely, Schistosoma mansoni, S.haematobium and S.intercalatum are responsible for causing Schistosomiasis in Africa, of which the most important ones are S.mansoni and S.haematobium that cause intestinal and urinary schistosomiasis, respectively (Harrison, 2005; van der Werf et al., 2003; Vennervald et al., 2004) Both, intestinal and urinary schistosomiasis are major public health problems in Tanzania where levels of endemicity vary from place to place (Mazigo et al., 2012) In 2012 it was reported that of the estimated population of 43.5 million people, nearly 23.2 million were infected with schistosomiasis forming a country prevalence of about 51.5% making the country rank second to Nigeria in terms of disease burden in Africa (Mazigo et al., 2012; Rollinson et al., 2012; van der Werf et al., 2003) In particular, Schistosoma mansoni in the country is extensively distributed in the south-eastern and south-western sides of Lake Victoria and its islands (Mazigo et al., 2012; McCullough, 1972) In these areas it has been reported to significantly affect people, mostly schoolchildren contributing significantly to their morbidities and mortalities (Kinung'hi et al., 2014; Kinung'hi et al., 2015; Mazigo et al., 2015; Munisi et al., 2016a)

Praziquantel chemotherapy has been the mainstay for schistosomiasis control in many endemic countries (Mekonnen et al., 2013) The target of Schistosomiasis Praziquantel mass chemotherapy in endemic countries has been to control morbidity associated with the disease and in certain epidemiological settings, contribute to sustained reduction in transmission of the disease (Savioli et al., 2009; WHO, 2002, 2006) In these areas treatment is implemented at periodic intervals, as part of either school or community-based campaigns, referred to as mass drug administration (MDA) (Chipeta et al., 2013) However in 2012, through World Health Assembly Resolution 65.19, the WHO recommended that countries, if possible, aim

beyond control of morbidity toward elimination of Schistosomiasis as also stated in the sustainable development goals for all neglected tropical diseases (Castleet al., 2014; UN).

Praziquantel has been shown to have good cure efficacy in killing both mature worms (Sabahi et al., 1986) However, the use of a single dose 40 mg/kg has limitations as PZQ does not kill immature worms present in the body at the time of treatment (Doenhoffet al., 2008; Sabahi et al., 1986). When Praziquantel is used in the first dose, it will kill the adult stages only, and in endemic areas chances of having developing immature stages quite high and these ones are not going to be killed by the first dose, instead as they mature they are likely to be exposed to sub lethal doses of Praziquantel therefore increasing chances of developing resistance. In that case, application of a second Praziquantel dose at week 6-8 will kill those parasites which were immature during the first dose as they will have matured by then, therefore in so doing, there will be an improvement on the cure rates and egg reduction rate which in turn will slow down the likelihood of the parasite developing resistance to the drug as well as significantly reducing environmental contamination by eggs discharged by infected people and therefore contributing to the efforts of achieving transmission control (Doenhoff et al., 2008; Garba et al., 2013; Jordan, 2000; Sabahi et al., 1986; Jürg Utzinger et al., 2003).

This restricted activity to adult worms and eggs may contribute to reduced efficacy of Praziquantel, and also contribute to raising population of adult parasites that have once been exposed to the drug, and possibly contribute to emergency of Praziquantel resistance (Sabahi et al., 1986). This speculation is supported by studies elsewhere which have reported reduced sensitivity of Schistosoma mansoni to Praziquantel and a failure of complete cure in a S.mansoni infection with a standard dose (Doenhoff et al., 2009; Garba et al., 2013; Obonyo et al., 2010; Sabahi et al., 1986; Wolfe, 2003). In Tanzania, a study done in Mara region showed that even a single Praziquantel treatment could produce a genetic bottleneck with reductions in a range of measures of genetic diversity of Schistosoma mansoni, reduction in genetic diversity may be an initial sign of emerging resistance or reduced sensitivity to the drug (Norton et al., 2010) Because of this, investigating alternative treatment strategies that may help to prolong the usefulness of the drug such as administering multiple doses is highly important (Doenhoff et al., 2009; Utzinger et al., 2011; Webster et al., 2013) In addition, administering more than one treatment may increase cure rate, thereby significantly hasten efforts to achieve transmission control by 2030 as stated in the sustainable development

goals (United Nations, 2015). Therefore this study intended to investigate the efficacy of single and repeated dose Praziquantel treatments on *S. mansoni* infection and its implication on the burden of undernutrition and anaemia among primary schoolchildren living in an endemic area in Rorya district, north-western Tanzania.

4.2 Methodology

4.2.1 Study Design and Population

This study was done in Rorya district, North-eastern Tanzania in 2015 to 2016. The district forms one of the seven districts that constitute the Mara region. It borders Tarime district to the east, Lake Victoria to the west, Butiama district to the south and the Republic of Kenya to the North (Webber and Chirangi, 2014). The Luo tribe constitutes the majority of inhabitants of Rorya District. Other ethnic groups are Kurya, Kine, Simbiti, Sweta and Suba. The District is situated in the North of Tanzania and lies between latitudes 1° 10' 45" south of the Equator and longitudes 33° 36' 0" and 35° 0" east of Greenwich Meridian. A more detailed description of the study area is found in our previous publication (Mumisi et al., 2016a). The current study was a longitudinal randomized intervention trial with a registration number PACTR201601001416338 registered on the Pan African Clinical Trial Registry. The longitudinal randomized intervention trial aimed at comparing the efficacy of single dose 40mg/kg against repeated dose 40mg/kg Praziquantel treatment regimens on parasitological (egg reduction rate and cure rates) and morbidity (Haemoglobin and Nutritional status) indicators with cure rate being the primary outcome of interest.

The study population consisted of primary schoolchildren aged 6-16 years attending primary schools in two villages of Busanga and Kibuyi in Rorya district. The inclusion and exclusion criteria were as described by Mumisi et al. (2016b)

4.2.2 Sample Size Determination

This study was a longitudinal intervention trial which aimed at comparing parasitological cure rates of single vs. repeated doses Praziquantel treatments for the treatment of intestinal schistosomiasis. We used a formula for calculating sample size aimed at comparing two rates to calculate the sample size for this study (Kirkwood, 2003). Parasitological cure rates of praziquantel against intestinal schistosomiasis reported from a study of communities living along the shores of Lake Albert in Uganda, which reported cure rates of 41.9% and 69.1% for

the single dose and two doses treatment regimens, respectively, was used (Kabatereine et al., 2003) The level of significance was set at 95% and power of 90%. We added 30% to counter annual loss to follow-up, a total sample size of 257 schoolchildren was required per treatment group. The sampling procedure was as described in our previous publication (Munisi et al., 2016b).

4.2.3 Data Collection

(i) Assessment for Demographic Characteristics

A pre-tested Swahili translated semi-structured interview questionnaire was used to gather demographic information about the study participants. Variables such as age, sex, socio demographic characteristics were assessed. Initially the questionnaire was developed in English; it was then translated to Swahili and back translated to English by a different person who was blinded to the original questionnaire.

(ii) Stool Sample Collection and Examination

Stool containers and wooden applicator sticks were provided to children with signed informed consent forms from their parents or legal guardians, the children were then requested to bring sizable stool samples of their own. We collected a single stool sample from each study participant. To increase sensitivity a standard protocol with four Kato-Katz thick smears were prepared from different parts of the single stool sample using a template of 41.7 mg (Vestergaard Frandsen, Lausanne, Switzerland) (Katz et al., 1972; WHO, 1991, 2002) Examinations of Kato smears for hookworm eggs were performed within 1 hour of slide preparation. Then the Kato smears were arranged in wooden slide boxes, packed together in large container boxes and transported to the National Institute for Medical Research (NIMR) laboratory, Mwanza Research Centre where they were examined for *S. mansoni* eggs by two experienced laboratory technicians. The Intensity (eggs per gram (EPG) of faeces of *S. mansoni* infection for each child) was calculated as an average egg per gram of faeces for all the four Kato smears prepared for each child. We used a template delivering 41.7 mg of stool to prepare Kato slides, the eggs of each parasite in the slide was counted and the number of eggs was multiplied by 24 to calculate EPG for *S. mansoni* infection. *Schistosoma mansoni* intensities were categorised as per WHO intensity classes as light (1-99 epg), moderate (100 -399 epg) and heavy (≥400 epg) (WHO, 2002). A random sample of 10% of the negative

and positive Kato Katz thick smears were examined by a third technician as a quality assurance procedure.

(iii) Anthropometric Measurements

The children's heights and weights were measured using a portable stadiometer and digital weighing scale, respectively. The children's barefoot stature and weight with minimum clothing and without shoes were recorded to the nearest 0.1 cm and 0.1 Kg respectively. The resulting height and weight measurements were used to calculate z-scores using the new World Health Organization Child Growth Standards (WHO, 2007). Any child with height-for-age z scores (HAZ) and BMI-for- age z scores (BMIAZ) below or equal to -2 standard deviation (-2SD) was classified as stunted and wasted, respectively. Those children whose HAZ and BMIAZ were less or equal to -3 standard deviation (-3 SD) were classified as severely stunted and severely wasted, respectively. Body mass index (BMI) was used as the index of choice for the assessment of recent undernutrition as recommended (Bailey and Ferro-Luzzi, 1995). We took all anthropometric measurements with instruments that were calibrated and validated before use.

The age of each participant was recorded from school records as reported by parents/guardians during school registration of the children. We used the midpoint of the year of birth, and the 15th day of the month of birth.

(iv) Determination of Haemoglobin Levels

About 100µl of blood were collected by finger prick using disposable lancet, this was used to determine venous Haemoglobin (Hb) by using a HaemoCue photometer (HemoCue, Angelholm, Sweden) (Von Schenck et al., 1986). Children with Hb levels more or equal to 11g/dL were considered to be normal. Anaemia was defined as Haemoglobin levels of less than 11g/dL while Haemoglobin levels of less than 7g/dL, 7.0-9.9g/dL and 10.0-10.9g/dL were classified as severe anaemia, moderate anaemic and mild anaemia, respectively (WHO, 2001).

4.2.4 Randomisation and Treatment

For assignment to the type of treatment regimen, children with positive stool test for Schistosoma mansoni were randomly divided into two groups using SPSS generated random

numbers after entering all collected data from the baseline survey. One group did not receive a second dose of 40 mg/kg PZQ, therefore this was the single treatment arm i.e. only treated at baseline. The second group was assigned to receive a second dose of 40 mg/kg of body weight PZQ with a 3-week interval. Treatment was given using tablets of PZQ USP 600 mg manufactured by Micro Labs Ltd, Verna, Goa India. The tablets were swallowed under the supervision of a qualified nurse involved in the study.

4.2.5 Data Analysis

We created a database of the collected data using EpiData version 3.1. The data were analysed using STATA version 12.1 (Stata corp, Texas, USA). In the descriptive analysis we used Simple frequency and percentages.

The cure rate was defined as the proportion of treated persons who were egg positive at baseline but became negative 8 weeks after baseline treatment. We used simple proportion comparison test to compare for cure rates between the two treatments regimens among different demographic characteristics. The egg reduction rate for those who remained positive was calculated as: (1-[AMI after treatment/AMI before treatment]) x 100. The Chi-square test and Fisher exact test were used to compare proportions of anaemia, stunting and wasting between the two treatments regimens for different demographic characteristics. Parasite counts were normalized by log transformation, averaged and then back transformed to the original scale. *S.mansoni* infection intensities were calculated as geometric mean of eggs per gram of faeces. A *p*-value of less than 0.05 was considered as statistically significant.

4.2.6 Ethical Statement

The study was approved by the Medical Research Coordination Committee (MRCC) of the National Institute for Medical Research (NIMR), Tanzania (Reference No. NIMR/HQ/R.8a/Vol. IX/1990). The study received further clearance from the District Executive Director, District Education Officer and District Medical Officer of the Rorya district council. Before commencement of the study, the research team conducted meetings with the village executive officers, teachers and pupils of selected villages and schools respectively. During these meetings, the objectives of the study, the study procedures to be followed, samples to be taken, study benefits and potential risks and discomforts were explained. Informed consent for all children who participated in the study was sought from

parents and legal guardians by signing an informed consent form. Assent was sought from children who were also informed of their right to refuse to participate in the study and to withdraw from the study at any time during the study. At baseline, all children were given a standard dose of praziquantel (40mg/kg) and albendazole (400mg) as a single dose on separate days. Treatment with praziquantel was given after a meal which was prepared and offered at school to minimize potential side effects. Treatment was performed immediately after baseline data collection and was done under direct observation (DOT) by a qualified nurse.

4.3 Results

4.3.1 BaselineCharacteristics of Study Participants and Trial Profile

During the baseline study we were able to recruit 256 schoolchildren for the single dose treatment group and 257 for the multiple dose treatment groups or a total of 513 schoolchildren for the whole study. Figure 2 shows the trial profile and compliance among study participants. A total of 431 schoolchildren were found to be infected with *Schistosoma mansoni* and were included in the trial. However upon randomization into the two treatments arms, 199 infected schoolchildren received a single 40mg/kg praziquantel dose and 184 infected schoolchildren received two praziquantel treatments three (3) weeks apart.

Cure rate and egg reduction rate was assessed at 8 weeks after first treatment and re-infection was assessed 5 and 8 months after the first treatment (baseline treatment). Table 10 shows baseline characteristics compared between individuals assigned to either of the two treatment arms. Characteristics of individuals were similar with regard to sex distribution, mean age, mean haemoglobin level, mean height and mean weight but they differed in the baseline geometric mean egg intensity in which case, infected children assigned to receive the two doses of praziquantel had significantly higher geometric mean egg Intensity (GMI) ($p=0.0352$) as well as Arithmetic mean egg Intensity (AMI) ($p=0.047$).

Table 10: Baseline characteristics of study participants

Characteristic	Single treatment n=199	Repeated treatments n=184	p-value
Sex, female (%)	102 (51.26)	100 (54.35)	0.545*
Mean age (95% CI)	11.05(10.73€ 11.37)	11.14(10.82€ 11.46)	0.6923**
Mean hb (95% CI)	11.51(11.32€ 11.70)	11.75(11.60€ 11.91)	0.055**
GMI (95% CI) epg	152.98(127.40€ 183.70)	203.00(167.81€ 245.56)	0.035**
AMI (95% CI) epg	344.71(261.13€ 428.30)	456.29(341.32€ 571.26)	0.047•
Mean height (cm) (95% CI)	134.55(133.15€ 135.96)	134.57(133.17€ 135.97)	0.9880**
Mean weight (Kg) (95% CI)	28.71 (27.87€ 29.54)	28.66(27.80€ 29.51)	0.9316**

* chi-square test, ** Student•s t test, ˆMann Whitney U test

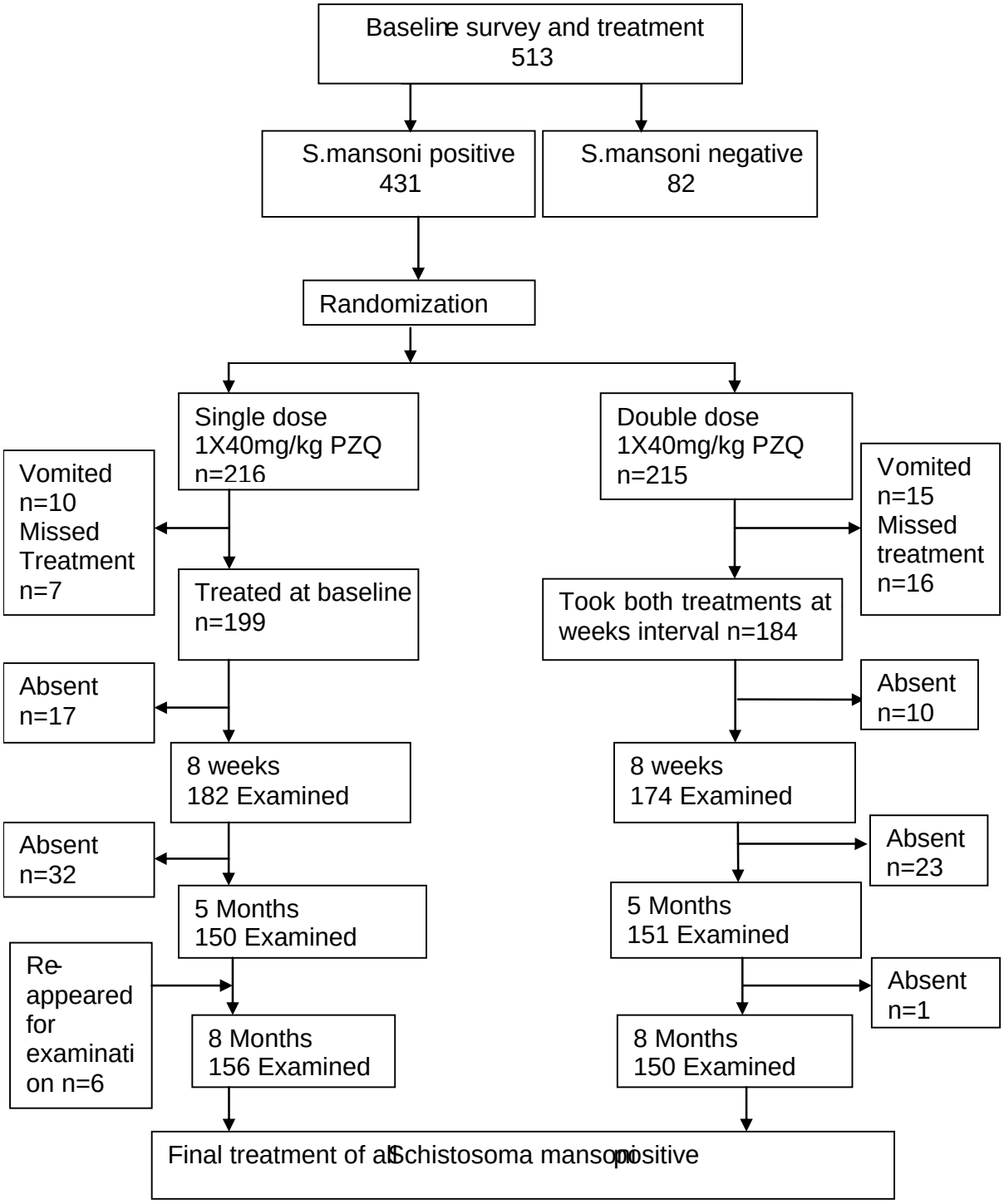

Figure 2: Study profile and compliance among 431 S.mansoni infected schoolchildren in an endemic area, North-western Tanzania.

4.3.2 Cure rate

Table 11 shows the cure rate according to sex, village of residence and age group of study participants on a single dose of PZQ (40 mg/kg PZQ) compared to two doses PZQ (2x40 mg/kg PZQ) three weeks apart, at 8 weeks after baseline treatment. A significant difference in cure rate was observed between the two treatment regimes, whereby the cure rate among infected schoolchildren who received two doses Praziquantel treatment (93.10%) was significantly higher compared to that among those who received a single dose Praziquantel treatment (68.68%) assessed 8 weeks following baseline treatment ($p<0.001$). This difference was still maintained when cure rates between the two treatment arms were compared for male, females and village of residence whereby in all cases cure rates were significantly higher among children who received two doses Praziquantel treatment ($p<0.05$). However, when cure rates was compared among subjects in different age groups, a significant difference in cure rates was observed among children of 6-9 years and 10-12 years age groups only. No significant difference on cure rates was observed among children aged 13-16 years who received single dose and two doses Praziquantel treatment ($p=0.080$) (Table 11)..

Cure rates was analysed by baseline infection intensity category for the two treatments arms. It was observed that, cure rates were significantly higher ($p<0.05$) among children who received two treatments than those who received single treatment among children with light, moderate and heavy intensity infections (Table 11).

Table 11: Cure rates of PZQ 40mg/kg stratified by demographic characteristics and baseline infection intensity

	Treatment regimen				
	Single dose		Double dose		
Characteristic	Treated(N)	Cured n (%, 95CI))	Treated (N)	Cured n (%, 95CI))	P=value
Overall	182	125 (68.68, 61.96€ 75.46)	174	162 (93.10, 89.31€ 96.89)	<0.001
Sex					
Male	89	66 (74.16, 64.94€ 83.69)	81	78 (96.30, 92.13€ 100)	<0.001
Female	93	59 (63.44, 53.54€ 73.35)	93	84 (90.32, 84.24€ 96.40)	<0.001
Village					
Kibuyi	96	61 (63.54, 53.86€ 73.28)	85	82 (96.47, 92.49€ 100)	<0.001
Busanga	86	64 (74.42, 65.08€ 83.76)	89	80 (89.89, 83.54€ 96.23)	0.007
Age (years)					
6-9	38	19 (50.00, 33.63€ 66.37)	39	38 (97.44, 92.33€ 100)	<0.001
10-12	84	60 (71.43, 61.64€ 81.22)	87	81 (93.10, 87.71€ 98.49)	<0.001
13-16	60	46 (76.67, 65.75€ 87.58)	48	43 (89.58, 80.75€ 98.41)	0.080
Intensity					
Light	64	47 (73.44, 62.41€ 84.46)	49	46 (93.88, 87.02€ 100)	0.005
Moderate	86	57 (66.28, 56.15€ 76.41)	66	63 (95.45, 90.35€ 100)	<0.001
Heavy	32	21 (65.63, 48.68€ 82.57)	59	53 (89.83, 81.95€ 97.72)	0.005

P-values are based on Chi square statistic

4.3.3 Impact of Single vs. Double Praziquantel Treatment on Intensity of Schistosoma mansoni Infection

The effect of the 2 treatment regimens on reduction of mean egg counts among schoolchildren who were found to be egg positive at 8 weeks, 5 months and 8 months post treatment is summarised in Fig. 3. At baseline there was a significant difference on the geometric mean egg intensity per gram of faeces, with children on the double treatment arm bearing higher geometric mean egg count (203.00 epg) than those in the single treatment arm (152.98 epg) ($p=0.0352$). At 8 weeks following baseline treatment, the geometric mean egg count was particularly low among children who received 2 doses of PZQ (1.30 epg) than those who received only one treatment dose (3.18 epg) and the deference was significant. It was further observed that geometric mean egg intensity of *S. mansoni* started to rise after a sharp decline at 8 weeks following baseline treatment. The geometric mean egg count at 5 months after baseline was slightly higher on the single dose arm (13.03 epg) compared to double dose arm (10.18 epg) but the difference was not statistically significant ($p>0.05$). Likewise, the geometric mean egg count at 8 months after baseline was again slightly higher on the single dose arm (18.14 epg) compared to double dose arm 15.94 epg but again the difference was not statistically significant ($p>0.05$) (Fig 3).

Egg reduction rate is the proportional reduction in number of *S.mansoni* eggs in stool samples. The baseline Arithmetic mean egg intensity (AMI) of individuals in the single dose arm was 344.71epg (CI95: 261.13 – 428.30) and it reduced to 43.88 epg (CI95: 11.33 – 76.43) following treatment resulting into an egg reduction rate of 87.27% (CI95: 79.93 – 92.89) while the AMI of individuals in the double dose arm reduced from 456.29 epg (CI95: 341.32 – 571.26) to 11.24 epg (CI95: 3.23 – 25.75), resulting into an egg reduction rate of 97.54% (CI95: 92.96 – 99.76) and the difference between these two egg reduction rates was statistically significant different ($p=0.0062$).

Figure 3: Infection intensity expressed as geometric mean of the log of fecal eggs count per gram of faeces at baseline, 8 weeks, 5 months and 8 months follwing treatment of S.mansoni infections with a single dose of PZQ (40mg/kg) vs. 2 X 40 mg/kg in the study area.

4.3.4 Re-infection with S.mansoni at 5 months and 8 months post treatment with a single praziquantel vs. double praziquantel doses

Re-infection is defined as those people who were positive for Schistosoma mansoni at baseline before treatment and became egg negative at 8 weeks following treatment but later became re-infected. At 5 months post baseline treatment, 74/161 (46.07%) people in the single treatment arm were re-infected while 102/150 (68.00%) in the double treatment arm were reinfected at this time. These rates of re-infection increased to 100/121 (82.64%) and 114/148 (77.03%) in the single and double treatment arms, respectively at 8 months following baseline treatment. The overall prevalence of re-infection was not statistically significantly different between the two treatment groups at 5 months ($p=0.742$) and 8 months ($p=0.256$). After stratification by sex, age and village of residence, there was only a statistically significant difference on the prevalence of re-infection between the two treatment groups among schoolchildren at Kibuyi village at 8 months post baseline treatment, whereby

children who were treated with a single dose Praziquantel treatment had a significantly higher prevalence of re-infection 61/67 (91.04%) as compared to those who were treated with two doses of Praziquantel three weeks apart 59/75 (78.64%) ($p<0.05$) (Table 2).

Table 12: Re infection with S.mansoniat 5 months and 8 months post treatment stratified by sex, village and age

Characteristic	5 Months					8 onths				
	1X40mg/kg		2X40mg/kg			1X40mg/kg		2X40mg/kg		
	Cured at week 8	Re-infected n (%)	Cured at week 8	Re-infected n (%)	P=value	Cured at week 8	Re-infected n (%)	Cured at week 8	Re-infected n (%)	P=value
	112	74 (66.07)	150	102 (68.00)	0.742	121	100(82.64)	148	114(77.03)	0.256
Sex										
Male	60	43(71.67)	69	45(65.22)	0.433	65	55(84.62)	71	59(83.10)	0.810
Female	52	31(59.62)	81	57(70.37)	0.201	56	45(80.36)	77	55(71.43)	0.239
Village										
Kibuyi	58	36(62.07)	72	38(52.78)	0.288	67	61(91.04)	78	59(75.64)	0.014*
Busanga	54	38(70.37)	78	64(82.05)	0.115	54	39(72.22)	70	55(78.57)	0.413
Age (years)										
6-9	17	13(76.47)	36	29(80.56)	0.732	28	22(78.57)	39	35(89.74)	0.206
10-12	56	35(62.50)	73	51(69.86)	0.379	53	45(84.91)	75	56(74.67)	0.162
13-16	39	26(66.67)	41	22(53.66)	0.235	40	33(82.50)	34	23(67.65)	0.138

4.3.5 Impact of Single vs. Double Praziquantel Treatment of *Schistosoma mansoni* Infections on Nutritional Status

The prevalence of stunting at baseline 40.21% (95%CI: 35.30%-45.12%) was compared with that 8 months after treatment 36.31% (95%CI: 31.17%-41.45%), although there was a slight decline on the overall prevalence, the difference was not statistically significant ($p=0.2833$). Prevalence of stunting at baseline and at 8 months post treatment was compared among individuals who received a single dose of Praziquantel and those who received two doses of Praziquantel three weeks apart. Although in both treatments arms there was a slight decrease of the prevalence of stunting, more so among children on two Praziquantel doses, the difference was not statistically significant ($p>0.05$) (Table 13).

Again the prevalence of wasting at baseline 14.10%(95%CI: 10.61%-17.59%) was compared with that 8 months after treatment 24.40% (95%CI: 19.82%-28.99%), It was observed that generally, the prevalence of wasting was significantly higher at 8 months after treatment than how it was at baseline ($p<0.001$). The prevalence of wasting at baseline and at 8 months post treatment was further compared among individuals who received a single dose of Praziquantel and those who received two doses of Praziquantel three weeks apart. Although the prevalence of wasting was observed to be higher at 8 months after treatment, it was significantly so only among children who received two doses of Praziquantel ($p<0.001$) (Table 13).

Table 13: Comparison of proportion of people with stunting and wasting at baseline and at 8 Months post treatment

Morbidity	n	Prevalence at baseline % (95%CI)	n	Prevalence at 8 months % (95%CI)	P=value
Stunting					
Overall	383	40.21(35.30€ 45.12)	336	36.31(31.17€ 41.45)	0.2833
Treatment arm					
1X40mg/kg	199	38.19 (31.44-44.94)	175	37.14 (29.98-44.30)	0.8344
2X40mg/kg	184	42.39 (35.25€ 49.53)	161	35.40(28.01€ 42.79)	0.1844
Wasting					
Overall	383	14.10(10.61€ 17.59)	336	24.40 (19.81€ 28.99)	<0.001
Treatment arm					
1X40mg/kg	199	15.58 (10.54-20.62)	175	22.29(16.12- 28.45)	0.0970
2X40mg/kg	184	12.50 (7.72-17.28)	161	26.71 (19.87-33.54)	0.0008

4.3.6 Impact of Single vs. Double Praziquantel Treatment of *S. mansoni* Infections on Haemoglobin Levels

The baseline mean haemoglobin levels in both treatment arms was compared with that at 5 months and 8 months after baseline treatment. In the single dose Praziquantel treatment arm, the baseline mean haemoglobin levels 11.51g/dL (95%CI: 11.32-11.70) did not differ significantly with that at 5 months after baseline treatment 11.40 g/dL (95%CI: 11.17-11.62) ($p>0.05$) but it was significantly smaller as compared to that at 8 months post baseline treatment 13.10g/dL (95%CI:12.95-13.25) ($p<0.001$). Likewise, in the two doses Praziquantel treatment arm, the baseline mean haemoglobin levels 11.75g/dL (95%CI: 11.60-11.91) did not differ significantly with that at 5 months after baseline treatment 11.62 g/dL (95%CI: 11.40-11.85) ($p>0.05$) but it was significantly smaller as compared to that at 8 months post baseline treatment 13.09g/dL (95%CI:12.93-13.23) ($p<0.0001$) (Figure 4). No significant difference was observed when mean haemoglobin levels at 8 months post baseline treatment was compared between the two treatment groups ($p=0.1374$).

The increase on the mean haemoglobin levels at 8 months after baseline treatment resulted into a decrease on the prevalence of anaemia. The prevalence of anemia at baseline 29.43% (95%CI: 25.49%-33.38%) was compared with that 8 months after treatment 3.84% (2.09%-5.63%). It was generally observed that, the baseline prevalence of anemia was significantly higher as compared to that at 8 months post treatment ($p<0.001$). The prevalence of anemia at baseline and at 8 months post treatment was compared among individuals who received a single dose of Praziquantel and those who received two doses of Praziquantel three weeks apart. It was observed that, in both treatment arms, the prevalence of anemia 8 months post baseline treatment was significantly lower when compared to that at baseline ($p<0.001$).

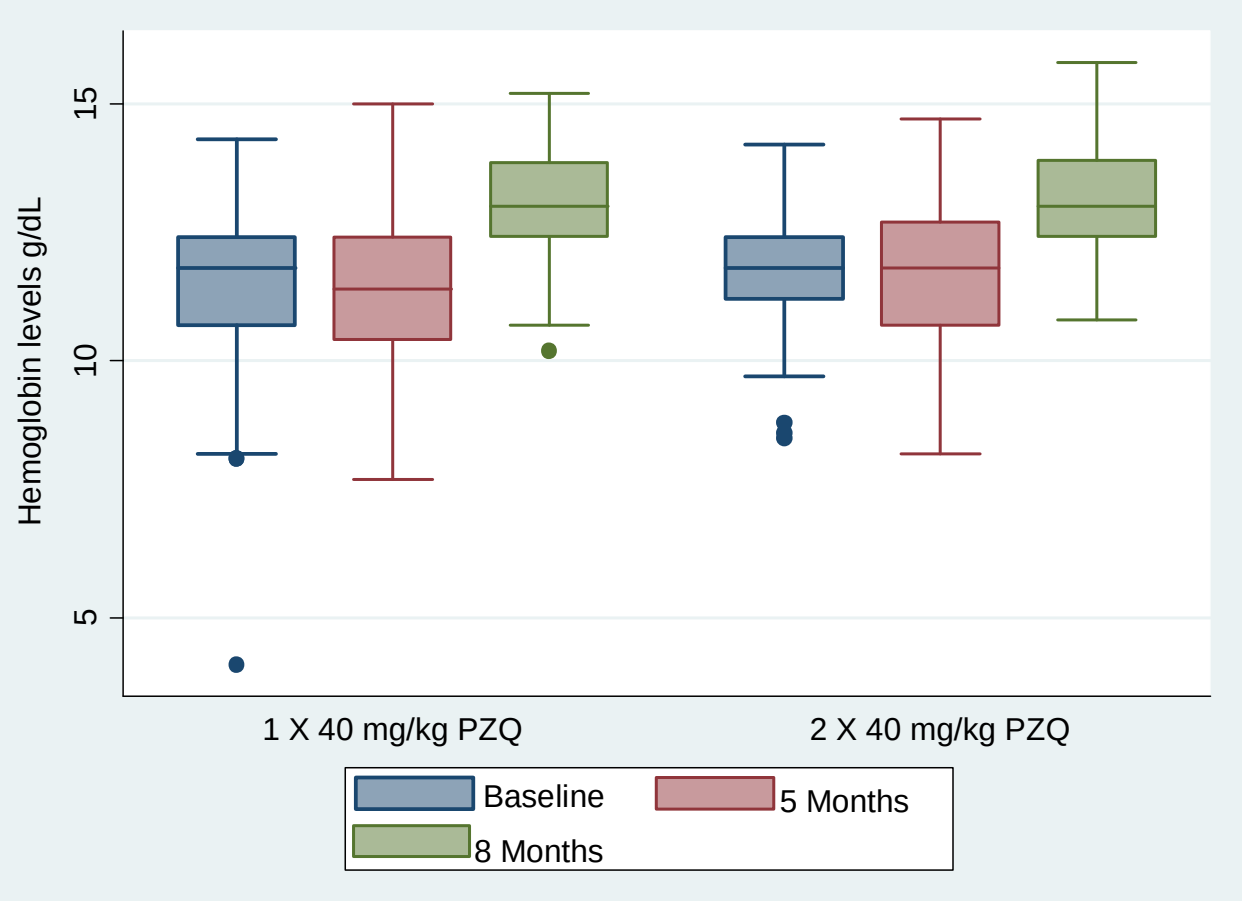

Figure 4: Box and whisker plot showing the relationship between median and range of haemoglobin levels g/dL at baseline (n=383), 5 months (n=321) and 8 months (n=332) post baseline treatment for the single dose and two doses praziquantel treatments. The thick line within each box stands for the median haemoglobin value. The lower and upper edge of each box represents the 25th and 75th percentiles, respectively. The lower and upper whiskers represent the lower and upper values (range), respectively, excluding outliers.

4.4 Discussion

Praziquantel restricted activity to adult worms and eggs may contribute to reduced efficacy of the drug and to raising population of adult parasites that have once been exposed to the drug, and possibly contribute to emergency of Praziquantel resistance (Sabah et al., 1986). Assessing alternative treatment regimen that would improve the drug's efficacy thereby significantly hastening efforts to achieve transmission control is of paramount significance. Therefore this study intended to investigate the efficacy of single and repeated dose praziquantel treatments on *S.mansoni* infection and its implication on the burden of undernutrition and anaemia among primary schoolchildren living in an endemic area in Rorya district, north-western Tanzania.

In this study, we examined the impact of two repeated doses of 40mg/kg Praziquantel administered 3 weeks apart compared to a standard single dose of 40 mg/kg with particular attention on cure rate, egg reduction rate (intensity of infection post-treatment) and its effect on the burden of anaemia and undernutrition among study participants.

At 8 weeks post baseline treatment, we found significantly higher cure and egg reduction rates among individuals who were treated with double praziquantel doses as compared to those treated with a single standard dose. Eight months post baseline treatment; we found that about 83% and 77% of those who were cured at 8 weeks after receiving a single treatment and two treatments, respectively, were re-infected. No significant difference was observed on the rates of re-infection both at five months and eight months after baseline treatment between the two treatment groups. It was further observed that, at eight months post baseline treatment, there was no difference on the prevalence of stunting between the two treatments regimens. However, we noted a significant increase on the prevalence of wasting among those on repeated dose than those on a single dose praziquantel. We further observed an increase on the mean haemoglobin levels at 8 months with no difference between the two arms.

The cure rate resulting from repeated Praziquantel treatments which is reported in this study is slightly higher compared to the upper margin of the possible cure rate resulting from single treatment (90%), while the cure rate resulting from single dose standard treatment lies close to the lower margin of the recorded cure rate of single dose Praziquantel treatment which is 60% - 90% (WHO, 2002). However, the cure rates reported in this study in both treatment

arms are relatively higher than what was reported by Kabatereine et al. (2003) 41.9% for single and 69.1% for double and Tukahebwa et al. (2013) 47.9% in single and 69.7% in double treatment arms. This difference on the observed cure rates for the two treatment regimens with those reported on the previous studies could be due to differences on the timing of the second treatment whereby in Kabatereine et al. (2003) the two treatments were given 6 weeks apart and in Tukahebwa et al. (2013) the two treatments were given 2 weeks apart and assessment was done at 6 weeks and 12 weeks, and 9 weeks post treatment, respectively (Kabatereine et al., 2003; Tukahebwa et al., 2013) contrary to this study in which the two treatments were given at three weeks interval and assessment was done at eight weeks following baseline treatment. Also, possibly because the drug has not been intensively used in the study area for Schistosomiasis mass chemotherapy. The relatively lower cure rate observed on the single dose treatment arm as compared to double treatment suggest that, since this is a *S.mansoni* endemic area (Munisi et al., 2016a), it is likely that during the baseline treatment some infected children had both mature worms and immature worms which are normally less sensitive to Praziquantel (Doenhoff et al., 2008; Sabah et al., 1986). This population of immature Schistosomes that survived the first treatment, if left untreated, could result in adult parasites which are less sensitive to the drug. Administering a second treatment might result in killing those parasites which were immature at the time of the first treatment resulting into improvement of the cure rate as seen in this study and delaying development of resistance to the drug. It was further observed that the superiority of the cure rates resulting from repeated praziquantel treatment was observed across sex and village of residence, but it wasn't the case across age groups, we noted that there was no difference on cure rates among children aged 13-16 years who received single and repeated dose Praziquantel treatment. This observation could be attributed to the fact that, this age is the age at which highest prevalence is usually observed and because of their behaviour are prone to rapid reinfections after the first treatment such that when the second treatment is offered, infections acquired after the first dose will still be at the age at which they are less sensitive to the second Praziquantel and therefore the lack of significant difference on cure rate. This has also been reported as being a reason for low cure rate among children in this age group (Ramsan et al., 2004)

The primary objective for the currently used mass treatment programs in Schistosomiasis endemic areas is morbidity reduction through reduction of the intensity of infection following

treatment (Kabatereine et al., 2003). Double praziquantel doses resulted into a significantly higher egg reduction rate. Similar findings have also been reported in a different study (Sacko et al., 2009). The egg reduction rates reported in this study are within the recorded standard egg reduction rates of Praziquantel of over 80% or 90% (Cioli et al., 1987; Utzinger et al., 2000). The relatively higher egg reduction resulting from double doses could, as stated earlier, be linked to the fact that, in areas where transmission intensity is very high, like an area in which this study was done (Muniisi et al., 2016a), a single dose is not enough to kill all worms particularly the immature worms, therefore administering a second dose resulted into killing more worms and eggs resulting into the observed significantly higher cure and egg reduction rates (Sacko et al., 2009). In addition to this, the repeated dose treatments in our study lead to a significantly lower mean egg intensity among those who were not cured at 8 weeks after baseline treatment. This could have been of value as far as morbidity reduction is concerned had it been sustained, however in this study, no difference on geometric mean egg intensity between the two arms was observed at 5 months and 8 months post baseline treatment. This suggests that repeated treatments did not offer any added advantage on reducing Schistosoma related morbidity in highly endemic areas where infections with parasites at different developmental stages and rapid re-infections following treatment is a norm. To sustain the benefit of repeated treatments, treatment should be coupled with other control measures that will reduce the rate of re-infections following treatments such as behaviour change communication and sanitation (Colley et al., 2014). This has also been reported in another longitudinal study where treatments were done in different years and cure rates reported, it was observed that the year in which cure failures were the greatest, were also the year in which *S. mansoni* prevalence in snails was highest (Black et al., 2009).

It has been reported that the rate of re-infection with Schistosome parasites following Praziquantel treatment occurs rapidly with *Schistosoma mansoni* than with *Schistosoma haematobium* (Daffalla and Fenwick, 1982; Ernould et al., 2004; Garba et al., 2013; N'goran et al., 2001). Factors that determine the rate of re-infection with Schistosome parasites have been said to include baseline infection intensity, Schistosome species and local ecology (Ernould et al., 2004; Garba et al., 2013; Kahama et al., 1999). This study found an overall prevalence of re-infection at 5 months and 8 months not to be statistically significantly different between the two treatment regimens, similar to what was also observed elsewhere (Tukahebwa et al., 2013). This is likely to be as a result of the high transmission intensity in

the area where this study was conducted (Munisi et al., 2016a). However, a significant difference on re-infection rate was observed when it was analysed by village of residence. In Kibuyi village, a significant difference on re-infection rate was observed between the two treatments with those receiving two treatments having a significantly lower prevalence of re-infection at 8 months post baseline treatment. This observation could be as a result of the difference in transmission intensity between the two villages whereby Kibuyi having a relatively lower transmission intensity as reported in our earlier report (Munisi et al., 2016a).

Intestinal schistosomiasis has been shown to contribute to the high prevalence of malnutrition and anaemia among children in developing world and improvement on nutritional status and haemoglobin levels has been reported following treatment with Praziquantel (Assis et al., 1998; Assis et al., 2004; Koukounari et al., 2006; Leenstra et al., 2004). Although, our previous study among study participants could not establish the relationship between nutritional status and anaemia with *S. mansoni* infection (Munisi et al., 2016b), we assessed the comparative implication of treating infected children with single and repeated dose Praziquantel treatment on the overall burden of anaemia and undernutrition among study participants. As an indicator of chronic nutritional insult, stunting rates at 8 months after baseline treatment did not differ significantly between the two treatment arms; however, there was a general decline on the prevalence of stunting when compared to baseline prevalence in both arms, a decline which of course this study fails to empirically link to treatment intervention due to lack of dietary information with regard to the study participants and the lack of a placebo control group. Surprisingly and contrary to stunting, the study observed that there was an increase on the overall rates of wasting following treatment, with the prevalence of wasting being significantly higher among children who were given repeated Praziquantel treatments. This observation relates to what was reported elsewhere that *S. mansoni* infected children were less likely to be wasted than their uninfected counterparts (Mekonnen et al., 2014) In this case therefore, the slight improvement on linear growth as a result of treatment might have negatively affected weight and height based indices (BMIAZ) as reported in (Friedman et al., 2005; Mekonnen et al., 2014) or the observed increase on the prevalence of wasting might have been confounded by acute dietary deficiency during or close to the time of the follow-up survey.

It has further been shown that *S. mansoni* infections contributes on the burden of anaemia among schoolchildren in endemic areas (Ghani et al., 2015). Although our earlier study in the study area could not associate *Schistosoma mansoni* infections with anaemia (Munisi et al., 2016b), we assessed the comparative implication of single and repeated Praziquantel treatments on the burden of anaemia among study participants. We found that, there was a general increase on the mean haemoglobin levels among study participants on both treatment arms with ultimate significant decrease on the prevalence of anaemia following treatment among subjects in both treatment arms. Improvement on haemoglobin levels following Praziquantel treatment among *Schistosoma mansoni* infected individuals has also been reported in other studies (Koukounari et al., 2006; McGarvey et al., 1996; Olds et al., 1999). However, at 8 months post treatment, second dose of Praziquantel did not offer any added benefit on improvement on haemoglobin levels. This observation is likely to be due to the observed lack of difference on the prevalence of infection at 8 months, since morbidity to Schistosomiasis correlates with the intensity and duration of infection (King et al., 2006).

We acknowledge that the relatively higher baseline arithmetic mean/geometric mean egg intensity among individuals who received two treatment doses might have resulted into underestimating the efficacy of the repeated treatments on *S. mansoni* and its possible implication on nutritional status and anaemia.

4.5 Conclusion and Recommendation

The present study found a significantly higher cure rate and egg reduction rates resulting from repeated dose Praziquantel treatment three weeks apart, as compared to a single standard dose at eight weeks after baseline treatment. However, besides the two treatment regime resulting into a significantly higher cure and egg reduction rates, the rate of re-infections among study subjects was almost equal between the two treatment arms leading into the mean egg intensity becoming almost equal at 5 and 8 months after baseline treatment. To achieve, reduction of transmission intensity and ultimately disease control in highly endemic areas, repeated treatments needs to be coupled with other control measures such as behavioural change communication and improvement in water supplies and sanitation. The present study further noted no difference on the prevalence of stunting between the two treatment regimens, eight months after baseline treatment. This could be as a result of the

short follow-up period; we therefore recommend studies that will have a longer follow-up period to assess the potential benefit of repeated treatments on nutritional status.

Significant increase on the mean haemoglobin levels following Praziquantel treatment among Schistosoma mansoni infected individuals has also been reported several studies (Kabatereine et al., 2006; McGarvey et al., 1996; Olds et al., 1999). Overall, there was a general significant increase on the mean haemoglobin levels among study subjects in our study with no difference between the two treatment arms. This highlights the usefulness of the currently used treatment regimen with the aim of controlling morbidity including anaemia. However, when the goal is to reduce transmission and ultimately achieve disease control, repeated treatment could offer a better benefit as compared to single treatment regimen particularly in areas where rapid re-infection occurs following treatment.

CHAPTER FIVE

Knowledge, Attitude and Practices on Intestinal Schistosomiasis among Primary Schoolchildren in the Lake Victoria Basin, Rorya District, North-Western Tanzania[4]

Abstract

Background

School-age children, adolescents and young adults constitute the group that bears the highest burden of schistosomiasis. When developing a specific intervention to improve community health, existing knowledge, attitude and practices of the community must be taken into account. Therefore this study was designed to determine the schoolchildren's knowledge, attitude and practices on schistosomiasis in the study area.

Methods

A cross-sectional study was conducted in Busanga and Kibuyi villages involving 513 schoolchildren. A pre-tested questionnaire was used to collect socio-demographic data and assessed knowledge, attitude and practices on schistosomiasis among primary schoolchildren in the study area.

Results

Out of the 488 children interviewed, 391 (80.12%) reported to have heard of schistosomiasis. Majority 289 (73.91%) mentioned school to be the source of this information. Swimming in the lake, worms, witchcraft and mosquitoes were mentioned to be the cause of intestinal schistosomiasis. Fishing in the lake, drinking unboiled lake water, walking barefoot, and shaking hands were reported to be practices that may lead a person to acquire Schistosome infection. Only 156 (39.90%) of the study respondents reported to know the signs of intestinal schistosomiasis. Avoiding swimming in the lake, drinking boiled water and eating properly washed fruits were mentioned as preventive measures. Besides, 412 (84.77%) reported understanding that there was Schistosomiasis, 419 (85.86%) considered

[4] Published in BMC Public Health on 21st September, 2017.

Schistosomiasis as a dangerous disease and 418 (85.66%) believed that Schistosomiasis could be treated. Fishermen and schoolchildren were reported to be groups most at risk of Schistosomiasis. Furthermore, 451 (92.42%) participants mentioned using lake water for domestic chores. While 407 (84.61%) reported to own a toilet at home, only 229 (55.31%) reported to always use the toilet. Visiting the lake was a common practice among study participants 471 (96.52%).

Conclusion and Recommendations

There is a high rate of awareness among schoolchildren regarding schistosomiasis but a good number of children have misconceptions on the cause, mode of transmission, symptoms and preventive measures for the disease. Therefore, an appropriate health education intervention is needed in order to inculcate appropriate knowledge on schoolchildren regarding its transmission, control and prevention.

Key words: Schistosomiasis, knowledge, attitude, practices, schoolchildren, Tanzania

5.1 Introduction

Schistosomiasis or bilharzias, is a neglected tropical disease (NTD) of public health importance in many developing countries in the tropics and subtropics (Ericson and Aagaard-Hansen, 2008). The disease occurs in 74 countries worldwide and it is estimated that about 207 million people are infected globally and nearly 779 million people are at risk of infection. Sub-Saharan Africa (SSA) accounts for more than 90% of the cases (Crompton, 1999; Steinmann *et al*., 2006). In Tanzania schistosomiasis is highly prevalent and the country ranks second after Nigeria in terms of disease burden in the African continent (Mazigo *et al*., 2012; Ross *et al*., 2002; Steinmann *et al*., 2006). Intestinal Schistosomiasis caused by *Schistosoma mansoni* is highly prevalent in areas surrounding the Lake Victoria in Tanzania (Mazigo *et al*., 2012; Lwambo *et al*., 1999). In these areas it has been implicated to cause considerable morbidity which correlates with the intensity of infection (Mazigo *et al*., 2012; Malenganisho *et al*., 2008). School-age children, adolescents and young adults are groups that bear the highest burden of disease resulting into significant impairment of their physical, nutritional and cognitive potentials (Crompton, 1999; Mazigo *et al*., 2012; Hotez and Kamath, 2009; Montresor *et al*., 2002; WHO, 2002).

Three key approaches can be used to control Schistosomiasis, these include: improved sanitation, health education and mass treatment with Praziquantel (Odhiambo *et al*., 2014). However, in many endemic areas including Tanzania, schistosomiasis control has largely relied on periodic mass treatment of school-age children with Praziquantel since its recommendation by WHO (Colley *et al*., 2014; Montresor *et al*., 2002). It is well known that lack of awareness about the mode of transmission of parasitic infections increases the risk of infection and therefore re-infection following treatment (Dawaki *et al*., 2015). Moreover, it has been reported that in high transmission settings, if there has been no change in the sanitary practices and exposure patterns, re-infection tends to occur within one year following treatment and tends to be higher among young children and adolescents than in adults due to acquired partial resistance to re-infections among adults following treatment (Kabatereine *et al*., 1999; Tukahebwa *et al*., 2013).

When trying to develop specific interventions aimed at improving communities knowledge attitude and practices, existing knowledge, attitude and practices must be taken into account (Musuva *et al*., 2014). These will inform bridging of identified gaps to enhance successful

disease control (Odhiambo et al., 2014). Furthermore, for interventions through community awareness and involvement of low socioeconomic communities it is recommended to create supporting environment for the success and sustainability of other strategies (Gyapong et al., 2000; Joshi and Banjara, 2008). The importance of this measure is even supported by the finding that health promotion interventions are likely to fail if they are designed without understanding the health behaviour of the target population (Mosuva et al., 2014).

Despite the fact that schistosomiasis is prevalent in many parts surrounding the Lake Victoria Basin in Tanzania, information on the knowledge attitude and practices on the disease of the most at-risk groups is scarce in the public domain. Therefore this study was designed to determine the schoolchildren's knowledge, attitude and practices on schistosomiasis in the study area.

5.2. Methods

5.2.1 Study Area

This study was conducted in Rorya district, Northwestern Tanzania. The district is bordered by Tarime district to the east, Butiama district to the south, Lake Victoria to the west, and the Republic of Kenya to the north (Webber and Chirangi, 2014). Detailed description of the study area is as it appears in Munisi et al. (2016a).

5.2.2 Study Design

This study was a cross-sectional baseline survey that assessed knowledge, attitude and practices on schistosomiasis among primary schoolchildren in selected schools in the study area.

5.2.3 Study Population, Inclusion and Exclusion Criteria

The study population comprised of primary schoolchildren aged 10-16 years attending pre-grade one to grade six in Busanga and Kibuyi primary schools in two villages of Busanga and Kibuyi, respectively. School children aged between 10-16 years, who gave assent to participate in the study and whose parents gave a written informed consent were eligible for the study. Schoolchildren with a history of being clinically ill and used anti-schistosome drugs within a period of six months before the study, were excluded as described in Munisi et al. (2016a).

5.2.4 Sample Size Determination and Sampling Procedures

This study formed the baseline survey of a longitudinal interventional study, which aimed at comparing cure rate and eggs reduction rate of two different treatment regimens for Intestinal schistosomiasis using praziquantel. Therefore the sample size was calculated using a formula for comparing two rates (Kirkwood, 2003). In the calculations we used cure rates reported from a study of communities living along the shores of Lake Albert in Uganda, which reported cure rates of 41.9% and 69.1% for single dose and two doses treatment regimen, respectively (Kabatereine et al., 2003). The level of significance was set at 95% and power of 90%. Adding 30% annual loss to follow up, a total sample size of 257 per treatment group was required, but we managed to recruit a total of 513 study participants for the entire study. Schools and sampling procedures are as described in detail in Mazigo et al. (2016a).

5.2.5 Data Collection

A pre-tested Kiswahili translated semi-structured questionnaire was used to collect information on demographic characteristics of the study participants, knowledge, attitude and practices towards *S. mansoni* infection. Variables such as age, sex, socio-economic activities of parents/guardians, sanitary practices, water contact behaviour and history of receiving anti schistosomal treatment were assessed. Also, the questionnaire involved questions concerning the knowledge about schistosomiasis aetiology, transmission, clinical manifestations, prevention and control. The questionnaire was initially developed in English and then translated to Kiswahili and back-translated by a different person who was blinded to the original questionnaire.

5.2.6 Data Analysis

All data collected was entered into a database using EpiData version 3.1. Data analysis was done using STATA version 12.1 (Stata corp, Texas, USA). Descriptive statistics were used to summarize the data. The chi-square test was used to assess association between categorical variables. P-values less than 0.05 were considered statistically significant.

5.3 Ethical Statement

The Medical Research Coordination Committee (MRCC) of the National Institute for Medical Research (NIMR), Tanzania, approved this study (Reference number NIMR/HQ/R.8a/Vol. IX/1990). The study received further approval from the District

Executive Director, District Education Officer, and Medical Officer for Rorya District Council. Prior to the commencement of the study, the research team conducted meetings with the village executive officers, teachers, and students of selected villages and schools, respectively. During these meetings, the objectives of the study, the study procedures to be followed, samples to be taken, study benefits, potential risks and discomforts were explained. Informed consent for all children who participated in the study was sought from parents and legal guardians by signing an informed consent form. Assent was sought from children who were also informed of their rights to refuse to participate in the study and to withdraw from the study at any time during the study. At baseline all children were given a standard dose of praziquantel (40 mg/kg) and albendazole (400 mg) as a single dose collection. Treatment with praziquantel was given after a meal which was prepared and offered at school to minimize potential side effects. Treatment was performed under direct observation (DOT) of a qualified nurse.

5.4 Results

5.4.1 Socio-Demographic Characteristics of the Study Participants

A total of 513 schoolchildren from the two primary schools were enrolled in the study. Out of these, 488 (95.13%) were interviewed. Of the interviewed children 238 (48.77%) were from Busanga village and 250 (51.23%) were from Kibuyi village. Among the study participants, 244 (50.00%) were males. The numbers of boys and girls in Busanga primary school were 117 (49.16%) and 121 (50.84%), respectively whereas the numbers of boys and girls in Kibuyi primary school were 127 (50.80%) and 123 (49.20%), respectively. The age of the schoolchildren ranged from 6 to 16 years with the mean age of 10.97 ± 2.36 years. The numbers of children with 6 – 9 years were 136 (27.87%), 10 – 12 years were 206 (42.62%) and 13 – 16 years were 146 (29.51%).

5.4.2 Respondent's knowledge on the cause, transmission, symptoms and preventive measures against Schistosomiasis

Of the 488 interviewed children, 391 (80.12%) reported to have heard about schistosomiasis, majority 289 (73.91%) of the children mentioned school to be one of the sources of information regarding schistosomiasis. Majority 339 (86.70%) of the children mentioned swimming in the lake to be the cause of schistosomiasis, while only 44 (11.25%) mentioned

that worms cause the disease. Witchcraft was mentioned by 15 (3.84%) of those who reported to have heard about the disease, while 13 (3.32%) mentioned mosquito to be responsible for causing intestinal schistosomiasis (Table 17). On activities that may lead one to get schistosome infection, majority of respondents 339 (86.7%) mentioned swimming in the lake while fishing was mentioned by 316 (80.86%) children. Drinking unboiled water was mentioned by 251 (64.19%) study participants while walking barefooted and shaking hands were mentioned by 220 (56.27%) and 142 (42.53%), respectively. In terms of knowledge of symptoms for intestinal schistosomiasis, only 156 (39.90%) of the study respondents reported to know the symptoms for intestinal schistosomiasis, majority of which 136 (87.18%) mentioned stomach ache to be one of the symptoms for intestinal schistosomiasis. Majority of the study respondents 306 (78.26%) mentioned avoiding swimming in the lake as one of the preventive measures for intestinal schistosomiasis, Avoiding drinking unboiled water and washing fruits before eating was also mentioned by 232 (59.34%) and 251 (64.19%) respondents, respectively (Table 17).

5.4.3 Attitude, Risk Perception and Practices of Study Participants towards Schistosomiasis

Majority of children 412 (84.77%) understood that there was schistosomiasis in their village of residence. Among the interviewed children, 419 (85.86%) considered schistosomiasis to be a dangerous disease while 405 (85.66%) understand that the disease can be treated (Table 18). Majority of study respondents 354 (81.76%) reported that fishermen were the most risk group for intestinal schistosomiasis, schoolchildren were also mentioned to be among the at-risk group by 325 (75.06%) participants (Table 18). The most common source of water used for domestic chores was Lake Victoria water, this was mentioned by 451 (92.42%) of study participants (Table 18). Toilet ownership was common whereby 407 (84.61%) reported to have a toilet at home with the main toilet type being pit latrine 299 (62.16%). There were significantly more children who reported not to have a toilet at home in Busanga (25.32%) than Kibuyi (6.048%) ($p<0.001$) (Fig 5). However, only 229 (55.31%) reported to always use a toilet, others 185 (44.69%) reported to use a toilet only sometimes. Defecating in the bushes was reported by 184 (98.91%) of those who use the toilets only sometimes and 154 (84.15%) reported to also defecate along the lakeshore. Visiting the Lake was a common practice among study participants whereby 471 (96.52%) of the study respondents reported to visit the lake of whom 412 (87.85%) reported to do that every day (Table 18). Just about

more than half (50.84%) of the respondents in Busanga village reported to use toilet only sometimes, while it was only 40% in Kibuyi village, the difference was statistically significant (p=0.028) (Fig. 6).

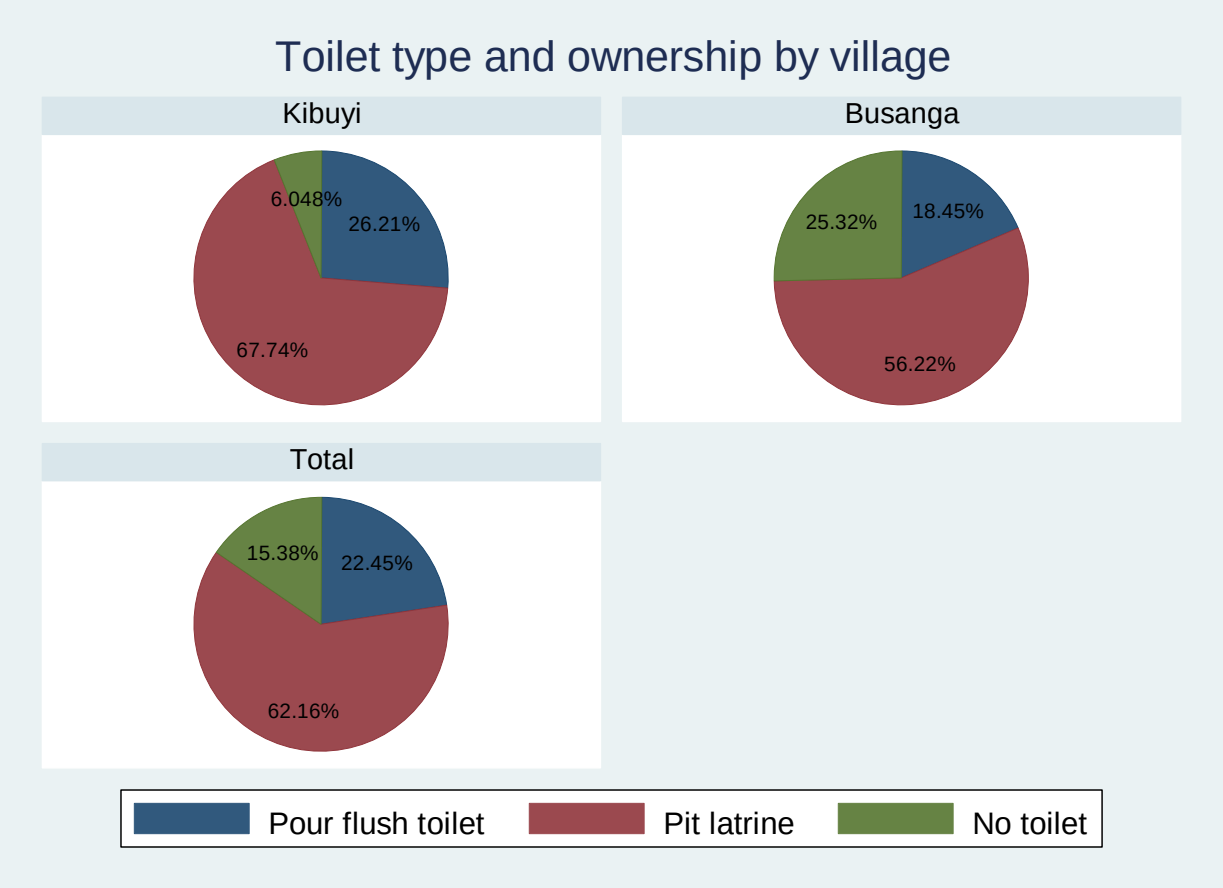

Figure 5: Toilet type and ownership by village of residence

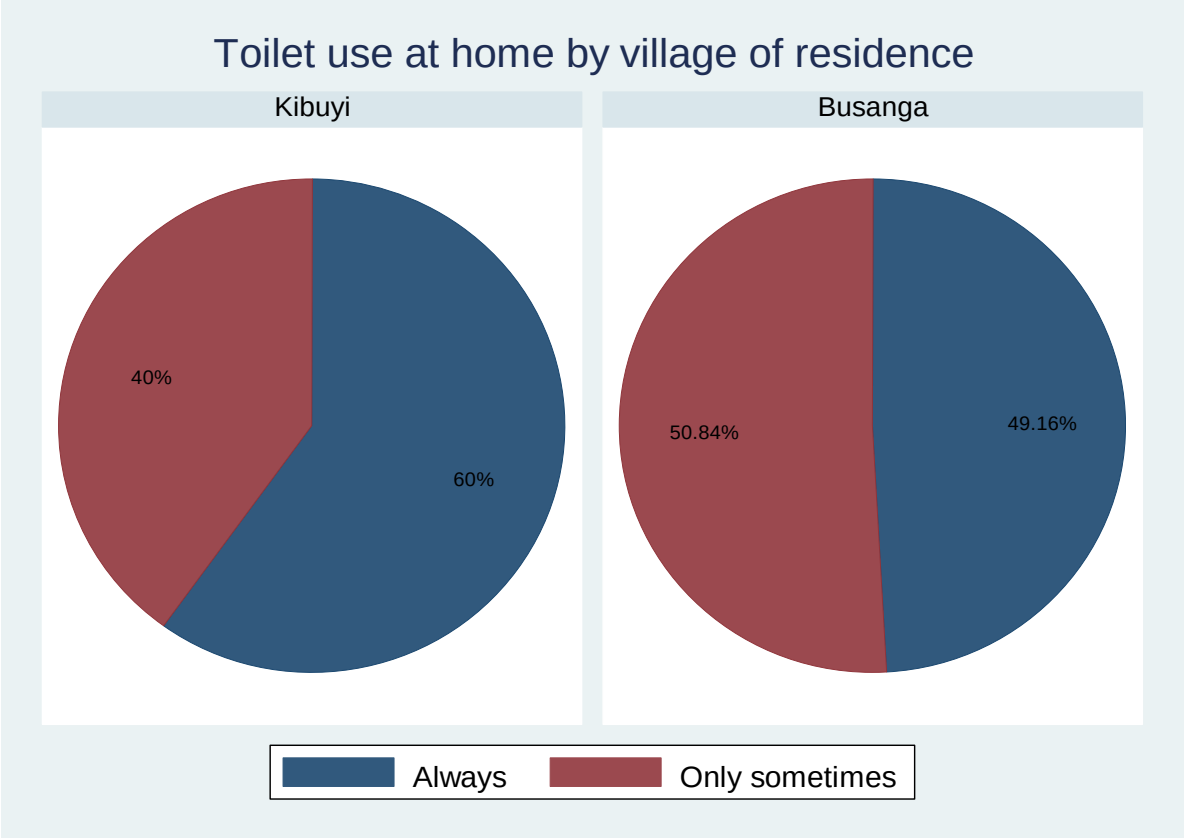

Figure 6: Toilet use at home by village of residence

Table 14: Respondents€ knowledge on the cause, transmission, symptoms and preventive measures against Schistosomiasis

Variable	Frequency	Percentage
Ever heard of Schistosomiasis (n=488)	391	80.12
Source of information (n=391)		
School	289	73.91
Home	149	38.11
Local dispensary	53	13.55
News media	93	23.79
Causes of Schistosomiasis (n=391)		
Worms	44	11.25
Mosquitoes	13	3.32
Witchcraft	15	3.84
Swimming in ponds	102	26.09
Swimming in river	49	12.53
Swimming in lake	339	86.70
I don•t know	37	9.46
Transmission of intestinal schistosomiasis		
Activities that may lead a person to acquire intestinal schistosomiasis (n=391)		
Swimming in the lake	339	86.70
Fishing in the lake	316	80.82
Washing clothes in the lake	251	64.19
Washing dishes in the lake	220	56.27
Drinking unboiled water	267	67.77
Walking barefooted	188	48.08
Shaking hands	49	12.53
Signs for intestinal schistosomiasis (n=156)		
Know the signs for intestinal schistosomiasis	156	39.90
Blood in urine (Haematuria)	81	51.92
Painful urination	40	25.64
Stomach ache	136	87.18
Swelling abdomen	61	39.10
Preventive measures for intestinal schistosomiasis (n=391)		
Avoiding swimming in the lake	306	78.26
Wearing gum boots when coming in contact with la water	258	65.98
Always using toilets	289	73.91
Avoiding touching the soil	117	29.92
Washing hands	169	43.22
Avoiding drinking unboiled water	232	59.34
Washing fruits before eating	251	64.19

Table 15: Attitude, risk perception and practices of the study participants towards Schistosomiasis

Variable	Frequency	Percentage (1%)
Source ofwater used at home (n=488)		
Tap water	39	7.99
Lake water	451	92.42
Bore hole	15	3.07
Open well	51	10.45
River water	16	3.28
Type of toilet at home (n=481)		
Pour flush toilet	108	22.45
Pit latrine	299	62.16
No toilet	74	15.38
Sanitary practices		
Always use toilet (414)	229	55.31
Use toilet only sometimes(414)	185	44.69
Sometimes defecate along the lake shore (183)	154	84.15
Sometimes defecate in the bushes (183)	181	98.91
Water contact habits (n=488)		
Visiting the lake	471	96.52
Frequency of visiting the lake (469)		
Once a month	11	2.35
2-3 times a week	46	9.81
Everyday	412	87.85
Risk perception (n=488)		
Schistosomiasis can be treated	418	85.66
There is schistosomiasis where I am living	412	84.77
schistosomiasis is a dangerous disease	419	85.86
Schistosomiasis is a chronic disease	40	8.20
schistosomiasis is a shameful disease	4	0.82
schistosomiasis is not a very dangerous disease	21	4.30
I don•t know	4	0.82
Most at risk groups (n=433)		
School children	325	75.06
Women	58	13.39
Rice farmers	32	7.39
Fishermen	354	81.76

5.5 Discussion

The success of schistosomiasis control interventions in endemic areas can be realized if children who are the targets of the currently used control interventions have adequate knowledge, positive attitudes, and correct preventive and control practices. This study aimed at exploring the level of knowledge, attitude and practices of schoolchildren on schistosomiasis that forms an important aspect towards developing appropriate control strategies.

This study found that majority of respondents had heard about intestinal schistosomiasis, other studies elsewhere reported more or less similar findings (Dawaki et al., 2015; Maseko et al., 2016; Mazigo et al., 2010a; Odhiambo et al., 2014). However, just having heard about the disease is not sufficient, a proper understanding of the disease and its causes and mode of transmission is what is required (Musuva et al., 2014). It was further noted that about three quarters of respondents reported the school to be one of the sources of information, a finding which is similar to what has been reported elsewhere that the main source of information about schistosomiasis was schools implying that schools could probably be the best strategic channel for communicating health information to this most susceptible age group (Acka et al., 2010; Mazigo et al., 2010a; Midzi et al., 2011). Other studies reported the most common source of information about schistosomiasis to be family or neighbours in which case the knowledge tended to be so diverse, with varying levels of misconceptions (Dawaki et al., 2015).

Although majority of the study participants mentioned swimming in the lake to be one way by which intestinal schistosomiasis could be transmitted, visiting the lake was common in this community. This high rate of visiting the lake was also reported in another study whereby 84% of the children reported going to the lake (Mazigo et al., 2010a). Children also mentioned fishing as an activity through which schistosomiasis might be transmitted. The high level of knowledge on the way schistosomiasis is transmitted could be due to the endemicity of the infection in this community to the extent that this knowledge fails to influence their practice, since the disease has became part of the lives (Mwanje et al., 2016a). Surprisingly, only a few (11.25%) of the participants knew that the cause of schistosomiasis were worms, this low level of knowledge on the exact cause of intestinal schistosomiasis was also reported elsewhere (Acka et al., 2010; Maseko et al., 2016; Mazigo et al., 2010a).

Misconceptions about the true cause of schistosomiasis were also present amongst interviewed schoolchildren whereby witchcraft and mosquitoes were also mentioned to be the causes of intestinal schistosomiasis. Such misconceptions may be a hindrance to implementation of a successful control program; therefore they need to be clearly clarified before launching an integrated schistosomiasis control program in the area. It was further evident that more misconceptions about the true mode of transmission were held by many children in these communities 64.19% believed that schistosomiasis could be transmitted by drinking unboiled water; other misconceptions about the mode of transmission were walking bare footed and shaking hands, similar misconceptions have been reported by other studies (Mwanga and Lwambo, 2013; Odhiambo et al., 2014) As many inhabitants of these areas use lake water for domestic purpose including drinking and they do suffer recurrent acute water-borne infections this could have prompted them to also believe that intestinal schistosomiasis could be transmitted by drinking unboiled lake water (Xinhua, 2016).

Despite high rates of having heard about schistosomiasis, only 39.9% of the respondents reported to know the symptoms of schistosomiasis of whom majority mentioned stomach ache as the symptoms for intestinal schistosomiasis contrary to blood in stool which was the most commonly reported symptom associated with intestinal schistosomiasis in western Côte d•Ivoire (Ackaet al., 2010). Low level of awareness on the signs and symptoms of intestinal schistosomiasis has also been reported in Siphofaneni area in the Lowvelds of Swaziland (Masekoet al., 2016).

Despite majority of the respondents knowing that avoiding swimming in lake water may be preventive for schistosomiasis, yet visiting the lake was a common practice amongst study participants as stated earlier due to dependency on the lake as the source of water for domestic and economic use including fishing, swimming, washing utensils, drinking, cooking and drinking animals. Similar results were also reported in western Kenya (Odhiambo et al., 2014). Misconceptions on proper preventive practices against intestinal schistosomiasis were common among study participants. Things like avoiding drinking unboiled lake water and washing fruits before eating were reported as preventive measures for intestinal schistosomiasis. This was a misconception which could be based on the fact that the mentioned preventive measure applies to other water-borne infections which are also endemic in the area; children thought that these could also be applied to prevent intestinal

Schistosomiasis. The observed poor knowledge on the signs, symptoms and preventive measure against intestinal schistosomiasis among study respondents indicates lack of appropriate health education among this risk group which should be provided in combination with mass treatment campaigns to enhance children's knowledge and therefore influence positive practices which will lower infection and reinfection rates following mass drug administrations.

Our findings showed that majority of the respondents understood that there was schistosomiasis in their village of residence and considered schistosomiasis as a dangerous disease. A similar finding was also reported by other studies (Dawaki et al., 2015; Odhiambo, et al., 2014) Majority also admitted that the disease could be treated, as it was also reported by elsewhere (Mazigo et al., 2010a).

Respondents in this study consider fishermen and schoolchildren to be the most at risk group for schistosomiasis. These two groups were also perceived to be the most at risk groups in a different study (Odhiambo et al., 2014) Despite high knowledge on the mode of transmission of intestinal schistosomiasis and the reported high rate of toilet ownership, indiscriminate defecation practices were common among study participants. This implies that the knowledge on the mode of transmission for intestinal schistosomiasis could not influence children's practice. This may signify that behavioural change which are often more difficult to achieve is not guaranteed by awareness alone, it may require long periods of time to ensure compliance with healthier practices (Assaolu and Ofoezie, 2003; Dawaki et al., 2015) Similar findings have been reported elsewhere as it appeared inconvenient to go back home just to answer a call of nature when someone is away from home and no need to bother oneself when there was water around to clean themselves after responding to a call of nature close to lake water body (Dawaki et al., 2015; Mazigo et al., 2010a; Odhiambo et al., 2014) In another study participants reported that, in some cases where the toilets were present, people still preferred defecating in the bush where they found to be more comfortable as compared to pit latrines that were feared to house snakes and also were almost full in many cases (Odhiambo et al., 2014) These findings suggests that provision of toilets alone is not enough to eliminate the indiscriminate defecation practices, providing public education on the importance of properly using toilets in the control of schistosomiasis and other parasitic infections needs to be emphasized among the targeted populations (Dawaki et al., 2015).

The study further revealed that toilet ownership was low in Busanga than Kibuyi village and more respondents reported to have indiscriminate defecation practice in Busanga than Kibuyi village. This observation is likely to be due to the fact that Kibuyi village is more close to Musoma municipality which is the headquarter for Mara region and therefore because of this people are more likely to have better access to health information than people at Busanga village which is a bit far away from Musoma municipality, location of the household has been well mentioned to be a significant factor to the access and utilization of toilets (Mahama, 2013)

5.6 Conclusion and Recommendation

This study found that most schoolchildren in the two villages of Rorya district were familiar to schistosomiasis with majority mentioning schools to be the source of schistosomiasis information. Despite this high rate of awareness about schistosomiasis a good number of children had misconceptions about the true cause, mode of transmission, symptoms and preventive measures for intestinal schistosomiasis. Thus, an appropriate health education intervention and community mobilisation is highly recommended in order to enhance schistosomiasis prevention and inculcate a better knowledge of schoolchildren regarding its transmission and prevention. For an effective and successful control program against schistosomiasis, there is a need for provision of proper health education to the risk groups that serve both as the main source of infection and victims for the high disease burden.

CHAPTER SIX

6.0 General Discussion and Conclusions

6.1 General Discussion

In Schistosoma mansoni endemic areas, the need for alternative Praziquantel treatment strategies that may help prolong the usefulness of the drug is undisputable (Doenhoff et al., 2009; Utzinger et al., 2011; Webster et al., 2013). New treatment strategies that will increase the drug's cure rate thereby significantly hasten the success of efforts to achieve transmission control in endemic countries are of paramount significance (United Nations, 2015). However, developing a sound and effective Schistosomiasis control strategy requires a thorough understanding of the local epidemiology of the disease (Jordan, 2000). This study investigated the epidemiology of Schistosoma mansoni infections in Rorya district, Northwestern Tanzania, and investigated the comparative efficacy of a standard single dose versus repeated dose praziquantel treatments against Schistosoma mansoni infections and their implication on undernutrition and anemia among schoolchildren.

This study has found that Schistosoma mansoni infections is highly prevalent in the study area, a finding which is likely to be a result of lack of safe water supply system in the area, the high dependence of the surveyed community on lake water for different domestic and economic activities and the fact that there had been no any major disease control interventions implemented in the study area prior to this study. It was further observed that there was no difference on the prevalence and intensity of infection between sexes, signifying equal exposure pattern to cercariae infested water among boys and girls in the study area. Contradicting findings have been reported on the sexual predisposition to Schistosoma infections with some studies reporting boys being more affected than girls in which case higher exposure frequency to cercarial infested water among boys than girls and hormonal differences were suggested to be the likely cause for higher male predisposition to infections than girls (Belay and Solomon, 1997; Erko et al., 1991; Kabatereine et al., 2004; Tilahun et al., 1999; Tsehaie et al., 1998) while many others reported girls to be at an increased risk to Schistosoma infections than boys (Ademu et al., 2011; Essa et al., 2012; Worku et al., 2014). This controversy necessitates detailed studies that will illuminate sex predisposition to Schistosoma mansoni infections in endemic areas.

In addition, this study found prevalence and intensity of infection to be varying by village of residence, whereby children at Busanga were found to bear higher infection prevalence and intensity. This observation is partly likely to be due to high transmission intensity in Busanga due to higher indiscriminate defecation practices and low toilet ownership as reported in this study (Chapter 5). Again communities at Busanga having relatively higher dependency on lake water for domestic and economic activities can further explain this observed difference. Variation on intensity of parasite transmission and frequency of exposure to parasite infested water bodies has been reported to be responsible for variation of prevalence and intensity of *Schistosoma mansoni* by geographical area elsewhere (Gashaw et al., 2015). Further, the prevalence and infection intensity in this study were higher among children who reported to have had a history of stomach pain and those with a history of taking schistosomal drugs. This observation is in line with the knowledge that abdominal pain is one of the common presenting signs for intestinal schistosomiasis and as a helminth, *S. mansoni* is aggregately distributed with only a few individuals in a community harboring the most infections as a result of their exposure pattern and susceptibility to infection therefore likely to be rapidly re-infected following treatment had there not been a change in their exposure (Colley et al., 2013; Elbaz and Esmat, 2013).

This study further found that having no formal education among parents, parent being involved in fishing activities, parent being unemployed and inconsistent use of toilets were significantly associated with higher geometric mean *Schistosoma mansoni* egg count. Other studies elsewhere also reported infection with *Schistosoma mansoni* being associated with parent's level of education with those from illiterate parents having higher chances of being infected than those from literate parents (Hastuty et al., 2014; Matthys et al., 2007; Sady et al., 2013). *Schistosoma mansoni* is known to be a disease of poverty. Parents with no formal education are more likely to be poor with children under their households living in poverty and are more likely to involve themselves in activities that expose them to infections with *Schistosoma mansoni*. This study also found that children of fishing parents had higher *Schistosoma mansoni* geometric mean egg count than those with non fishing parents. This observation is likely to be as a result of children of fishing parents being more likely to start visiting lakes much more early in their life and have more frequent visits to the lake as compared to children of non fishing parents. As also reported in Bamako, Mali; children who reported their parents not being employed had higher mean parasite egg count per gram of

stool than children with parents who are employed (Deribo et al., 2015). Also children who reported to inconsistently use toilet when at home were more likely to be infected with Schistosoma mansoni as also reported elsewhere (Abou-Zeid et al., 2012; WHO, 2002). Following defecating on bushes and along the lake shore, children are likely to clean themselves in the lake, a practice that is to be responsible for the observed higher rates of infection among children who do not always use toilets when at home.

Undernutrition and anaemia among schoolchildren are still major public health problems in Tanzania (Leach and Kilama, 2009; Munisi et al., 2014). Among other factors, intestinal parasitic infections including Schistosoma mansoni are known to affect both growth and hemoglobin levels of infected children. In this study, it was observed that the prevalence of stunting and wasting was high based on WHO classifications of undernutrition while that of anaemia signified a moderate public health problem as per WHO classification of anaemia (de Onis et al., 1997; WHO, 2008). Although the prevalence of Schistosoma mansoni among schoolchildren was very high (84.01%), it was observed to be associated with neither undernutrition nor anaemia, an observation that suggests Schistosoma mansoni infection not to be an important factor in the aetiology of undernutrition and anaemia in this area as also reported in other studies elsewhere (Abdi et al., 2017; Mekonnen et al., 2014). This suggests that the observed high rate of undernutrition and anaemia is likely to be a result of chronic inadequate dietary nutrients and possibly chronic intestinal protozoal infections which were not assessed in our study but have been reported to be important causes for these morbidities (Battle et al., 2013; Gutiérrez et al., 2014).

This study further tested the comparative efficacy of the standard single dose versus repeated two doses praziquantel treatment among Schistosoma mansoni infected schoolchildren and its impact on the observed burden of anaemia and undernutrition. It was observed that at eight (8) weeks following baseline treatment, the cure rate and egg reduction rate among children who received two treatments was significantly higher as compared to that of children who received a single dose standard praziquantel treatment. These findings are similar to what was reported in other studies elsewhere (Kabatereine et al., 2003). It was further noted that the geometric mean egg intensity among those who were not cured at 8 weeks post baseline treatment was significantly lower among in children who received repeated treatment than those who received a single treatment. This difference was not noted at 5months and 8

months post baseline treatment possibly because of rapid re-infections following treatment. This therefore shows that in order to sustain the benefit derived from repeated treatments, efforts should be made to reduce the rate of acquiring new infections and contaminating the environment through methods such as behavior change and improvement of water sources and sanitation as also observed elsewhere (Colley et al., 2014). The improvement of cure rate and egg reduction rate following the second treatment is likely to be due to killing of parasite which were young and therefore less sensitive to the drug during the first dose as coexistence of mature and immature parasite in the same individual at the same time is very common in individuals living in endemic area like our study area (Daenhoff et al., 2008; Sabah et al., 1986). In endemic regions, the control of Schistosomiasis is a challenge mainly due to difficulties in preventing early infection and frequent re-infection following treatment (Andrade et al., 2017). As also reported in a similar study somewhere else, this study found no difference on the rate of re-infection at 5 months and 8 months post baseline treatment, though there was very high re-infection rate. Possibly this could be attributed to the high transmission intensity in the area where this study was conducted which closely relate to risk behaviors practiced by the surveyed community. When analyzed by village of residence, the rate of reinfection between the two groups was observed to be significantly different in Kibuyi village, whereby children who received two treatments had lower rate than those who received a single treatment. This observation is likely to be a result of the relatively lower transmission intensity in Kibuyi village as compared to Busanga village (Mwanzi et al., 2016a).

A number of studies have indicated that *Schistosoma mansoni* infections are associated with nutritional deficiencies and anaemia (Assis et al., 1998; Assis et al., 2004; Corbett et al., 1992; de Lima et al., 1988; Koukounari et al., 2006; Leenstra et al., 2004; Musgrove 1993; Parraga et al., 1996). Improvement on both nutritional status and haemoglobin levels have been reported following treatment with standard dose of praziquantel (Assis et al., 1998; Koukounari et al., 2006). The comparative impact of the two treatment regimes on the burden of undernutrition and anaemia was assessed. It was observed that stunting rate at 8 weeks post baseline treatment did not differ between the two treatment regimes. In contrast, there was an increase on the overall rate of wasting with children on the repeated treatments regime recording significantly higher rate of wasting following treatment. This observation is somewhat similar to what was reported by a different study that *Schistosoma mansoni*

infected children were less likely to be wasted than their uninfected counterparts (Mäkinen et al., 2014). However, this observed increase on the prevalence of wasting might have been confounded by acute dietary deficiency during or close to the time of the follow-up survey. It was further noted that, there was a significant increase on the mean haemoglobin levels among study participants in both treatment arms following treatment. This observation is similar to what was reported in previous studies (Koukounari et al., 2006; McGarvey et al., 1996; Olds et al., 1999). However in this study it was evident that offering the second treatment did not offer any added advantage on improvement of haemoglobin levels among treated individuals at 8 months following baseline treatment. This observation is likely to be due to the lack of difference on the rate of re-infections among individuals in the two treatment regimes much as morbidity due to *Schistosoma mansoni* is related to the intensity and duration of infection (King et al., 2006).

It has been shown that in areas where schistosomiasis transmission is very intense, re-infection tends to occur within one year following treatment if there has been no change in the sanitary practices and exposure patterns (Kabatereine et al., 1999; Tukahebwa et al., 2013). The rate of re-infection in both treatment arms in this study was very high and signified high risk behaviors and environmental contamination among Schoolchildren in the study area. We then assessed the level of Knowledge, attitudes and practices among study participants, to identify potential knowledge gaps, poor attitude and risk practices that may be addressed when developing a comprehensive control strategy. It is well known that understanding Knowledge, Attitudes and Practices in relation to a disease are critical in establishing effective control measures (Mwai et al., 2016). It was found that majority of the Schoolchildren had heard about Schistosomiasis with school being the most common source of information. Despite this high level of awareness, a good number of schoolchildren had a number of misconceptions on the cause, mode of transmission, symptoms and preventive measures for the disease. Furthermore, despite good knowledge of risk practices and proper preventive measure for intestinal Schistosomiasis such that, avoiding coming into contact with lake water visiting the lake was common among study participants. And because, indiscriminate defecation practices was common, a practice that lead to environmental contamination with faeces from infected people, coming into contact with water may explain the observed high rate of re-infection in this study.

6.2 Conclusions

The present study has demonstrated that the prevalence and intensity of infections with Schistosoma mansoni among schoolchildren in this study area is high. It was further noted that undernutrition and anaemia are also highly prevalent in the study area. Village of residence, parent's level of education, use of toilet at home and a history of ever being treated for intestinal Schistosomiasis were significant predictors of Schistosoma mansoni infections. Although a number of studies have associated Schistosoma mansoni infection with low haemoglobin levels and higher rates of undernutrition, the present study failed to demonstrate this association among schoolchildren. This observation suggests that the observed higher levels of anaemia and undernutrition are likely to be a result of inadequate intake of essential dietary nutrients.

Repeated dose praziquantel treatments three weeks apart documented a higher cure rate and egg reduction rate as compared to a single standard dose at weeks 8 and 12 after baseline treatment. Despite high rate of awareness about schistosomiasis, a good number of children not only had misconceptions about the cause, mode of transmission, symptoms and preventive measures for intestinal schistosomiasis but also had practices that continued to put them at risk of acquiring new infections and contaminating the environment, as evidenced by high re-infection rate after treatment in this study irrespective of the number of treatment. It was further noted that repeated treatments did not offer any added advantage on the reduction of prevalence of stunting and improvement on haemoglobin levels. However, when the goal is to reduce transmission and ultimately achieve disease control and delay the development of praziquantel resistance, repeated treatment could be of added benefit as compared to single dose treatment regimen particularly in areas where rapid re-infection occurs following treatment, when combined with other control measures that will reduce re-infection rates and environmental contamination.

6.3 Recommendations

(i) Public health interventions to control Schistosoma mansoni in the study area should take into consideration the associated risk factors demonstrated by this study. To achieve, reduction of transmission intensity and ultimately disease control in highly endemic areas, repeated treatments needs to be coupled with other control measures that will reduce the rate of re-infection following treatment and environmental

contamination with parasites eggs, such as behavioural change communication and improvement in water supplies and sanitation.

(ii) More detailed studies that will assess the contribution of *Schistosoma mansoni* infections on the burden of anaemia and undernutrition that will also assess dietary information and have a longer follow-up period are highly recommended.

(iii) School age children in Rorya district should be considered for inclusion into national schistosomiasis control and school feeding programmes.

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APPENDICES

Appendix 1: Informed Consent Form - English Version

NELSON MANDELA AFRICAN INSTITUTION OF SCIENCE AND TECHNOLOGY -ARUSHA

INFORMED CONSENT FORM

ID-NO_____

Consent to participate in the research study.

Greetings! My name is David Zadock Munisi from NELSON MANDELA AFRICAN INSTITUTION OF SCIENCE AND TECHNOLOGY -ARUSHA, PhD. LiSE Candidate. I am conducting a research project with the objective of ,Describing the epidemiology of Schistosomiasis and assessing the efficacy of single versus multiple doses of Praziquantel treatments among primary school children in Rorya district.

Study Purpose

The purpose of the study is to describe the current epidemiology of Schistosomiasis in this district and assess the comparative efficacy of single versus double dose Praziquantel treatment. Findings from this study will help to develop more effective intervention strategies for the disease in the district and country at large.

What Participation Involves.

If you agree your child to participate in the study, your child will be required to answer questions during interviews and to provide a finger prick blood sample for haemoglobin levels assessment. He/she will also provide stool samples to investigate Schistosome infections. The child will further be measured his/her height and weight during the day of sample collection. Children who will be positive for Schistosomiasis will be recruited into a cohort of study for drug efficacy assessment. And they will be given treatment and will have to offer stool and/or urine sample to assess presence of infection.

Confidentiality

Confidentiality will be observed by entering all collected information into computers with only the study identification number without involving names, and unauthorized persons will have no access to the data collected. The collected samples will only used for investigations stated in the study protocol

Benefits

If you allow your child to take part in this study, your child will benefit directly or indirectly. Directly, is when the child is found to be having Schistosomiasis will be treated, and if found to have anaemia will be refered to a nearby health facility for further investigation and treatment. Indirectly, is when the epidemiology of the disease is well known, effective control measures will be devised and this will reduce the risk for the child and other members of the family to suffer Schistosomiasis.

Potential Risks

I assure you that no harm will be expected to happen to your child because of participation in this study however during finger prick one may feel some pain and after taking the drugs there could be some undesired effects such as dizziness, nausea, and stomach ache. But these are of short duration and they will disappear.

Rights to Withdraw and Alternatives

Participation in this study is completely your choice. You can stop participating in this study at any stage, even if you have already given your consent. Refusal to participate or withdrawal fromthe study will not involve any penalty or loss of any benefits to which you are otherwise entitled.

I _____have read/listened the contents in this form. I agree my child to participate in this study.

Signature of the participant_____

Signature of the Principal Investigator_____Date of signed consent_____

Who to contact

If you happen to have questions about this study, you should contact,

David Zadock Munisi,

The Principal Investigator, of NM-AIST , P.O. Box 447, Arusha, TANZANIA (0713668857).

NatHREC, NIMR Headquaters , 2448 Barack Obama Drive , Ground Floor, NatHREC office

Prof J. Buza, The study Supervisor, of NM-AIST , P.O. Box 447, Arusha, TANZANIA (0767012616)

Appendix 2: Informed consent form ƒ Swahili version

TAASIS YA AFRIKA YA SAYANSI NA TEKNOLOGIA YA NELSON MANDELA

NAMBARI YA UTAMBULISHO YA MSHIRIKI_____

Ridhaa ya ushiriki katika utafiti

Habari! Jina langu ni David Munisi, natoka katika TAASIS YA AFRIKA YA SAYANSI NA TEKNOLOGIA YA NELSON MANDELA, mwanafunzi wa shahada ya uzamivu. Ninafanya utafiti wenye lengo kuu la kuchunguza Hali ya ugonjwa wa kichocho na ufanisi dozi moja au mbili za dawa ya kichocho katika kutibu ugonjwa wa kichocho katika mkoa wa Mara.

Lengo la utafiti

Utafiti huu unakusudia kuchunguza hali ya kichocho na ufanisi wa dawa ya kichocho. Matokeo katika utafiti huu yatasaidia kujua hali ya kichocho katika wilaya ya Rorya, na hivyo kubuni njia madhubuti za kuweza kuudhibiti ugonjwa huu katika wilaya hii na nchini kote kwa ujumla.

Iwapo utakubali mtoto wako ashiriki katika utafiti, mtoto ataombwa kujibu maswali katika dodoso atakayoulizwa na pia kutoa kiasi kidogo cha damu ya kidoleni kwa ajili ya kupima wingi wa damu. Pia mtoto atatakiwa kutoa choo kwa ajili ya kupima kichocho. Pamoja na hayo mtoto atatakiwa kupima uzito na urefu wake. Watoto watakaokutwa na maambukizi ya kichocho watapatiwa dawa pamoja na kuwaingiza katika ufuatiliaji.

Usiri

Usiri wa taarifaza mtoto utazingatiwa kwa kuingiza taarifa zote zitakazokusanywa katika computer kwa kutumia nambari ya utambuilisho bila kuandika jina la motto. Siri zote zitatunzwa na taarifa zilizokusanywa hazitamfikia yeyote asiyehusika katika utafiti huu.

Faida zakushiriki katika utafiti huu

Iwapo utakubali motto wako ashiriki katika utafiti huu, atapata faida za moja kwa moja na zisizo za moja kwa moja. Faida za moja kwa moja ni pamoja na kutibiwa iwapo atakutwa na maambukizi ya kichocho, na pia akikutwa na upungufu wa damu atapewa rufaa ya kwenda

kwenye kituo cha afya kwa ajili ya uchunguzi zaidi na matibabu. Pia utaweza kupata msaada kwa tatizo lolote litakalojulikana wakati wa utafiti huu.

Uwezekano wa kutokea jambo lolote la hatari.

Nakuhakikishia kwamba sitaji kama kuna hatari yeyote yaweza kutokea kwa sababu ya ushiriki wa motto wako katika utafiti huu. Pengine unaweza kuhisi maumivu kidogo tu kutokana na kuchoma kidole cha mkononi kwa ajil ya kupima wingi wa damu na Malaria, na pia kwa wale watakaokutwaan maambukizi na kasha kumeza dawa, wanaweza kujisikia kichefuchefu au kizunguzungu au maumivu ya tumbo kidogo. Hata hivyoathari hizi ni za muda mfupi, na zitakwisha ndaniya muda mfupi tu.

Haki ya kujitoa na mambo mbadala

Ushiriki wa motto wako katika utafiti huu ni wa hiyari yako na motto wako. Utaweza kusitisha ushiriki wa motto wako katika utafiti huu katika hatua yeyote hata kama ulishatoa ridhaa na kusaini fomu hii. Kukataa kushiriki au kujitoa katika ushiriki hakutahusisha adhabu yeyote au kupoteza haki zako zozote unazostahili.

Mimi _____ nimesoma/nimesomewa na kuyaelewa vyema maelezo yaliyomo katika fomu hii. Ninakubali mtoto wangu kushiriki katika utafiti huu.

Sahihi ya Mshiriki _____

Sahihi ya Mtafiti _____Tarehe ya kusaini _____

Kwa Maswali wasiliana na:

David Zadock Munisi,

Mtafiti Mkuu wa Utafiti huu, wa NM-AIST, P.O. Box 447, Arusha, TANZANIA (0713668857).

NatHREC, NIMR Headquaters , 2488 Barack Obama Drive , Ground Floor, NatHREC office .Prof J. Buza, Msimamizi wa Mtafiti, wa NM-AIST, P.O. Box 447, Arusha, TANZANIA (0767012616)

Appendix 3: Ethical clearance certificate

Appendix 4: Research Questionnaire/ English version

Research Questionnaire for Intestinal Schistosomiasis in Rorya District

1. Participant€s particulars

S/N	Particular	Response
1	Enumerator•s name (initials)	
2	Village name	
3	GPS points	
4	Hamlet name	
5	Dateof data collection	
6	Participant•s name	
7	Participant•s Identification number	

2. Demographic information

S/N	Variable	Codes	Remarks
8	Sex	1=Male 2=Female	
9	Age (Years)		
	Which grade are you?		
10	What is the level of education o your parent/guardian?	1=Never gone to schoo 2=Primary education 3=Secondary education 4=College education	

		5=University education 6=Others (name) 7=I don•t know	
11	What is the economic activity (ies of your parent/guardian?	1=Farmer/Livestock keeper 2=Fishing 3=Busıness 3=Employed 4=Others (name) 5=I don•t know	
12	For how long have you been stayi in this village?	1= Was born here ŒŒ(years) 2= ImmigrantŒŒ(years)	

3.0. Sanitary practrices

	Question	Code	Rema
13	Is there a toilet at school?	*0=Yes(Proceedɑt question 14) 1=No (Skip to question 16)	
14	If yes, how do you use the toilet at schoo	1= Always * 0=Yes 1= No 2= Only sometimes * 0=Yes (Proceed to question 15 1= No (Skip to question 17)	

		3= I do not use a toilet * 0=Yes (Proceed to question 16) 1= No (Skip to question 17)	
15	From question 14, If you only use toilets only sometimes, Where do you ease yourself at other time	1= Lake * 0=Yes 1= No 2= In the river * 0=Yes 1= No 3= In the bushes * 0=Yes 1= No 4= Others, name……	
16	From question 13and 14, If there is no toilet/don•t use toilet, Where do you ease yourself when at sch	1= Lake * 0=Yes 1= No 2= In the river * 0=Yes 1= No 3= In the bushes * 0=Yes 1= No 4= Others, name……	
17	What is the source of wáter you use at hc	1= Tap water * 0=Yes 1= No	

		2= Lake * 0=Yes 1= No 3= Bore hole * 0=Yes 1= No 4= Open shallow well * 0=Yes 1= No 5= River * 0=Yes 1= No	
18	What type of toilet do you use at home?	1= Modern flush toilet * 0=Yes 1= No 2= Pit latrine * 0=Yes 1= No 3= There is no toilet * 0=Yes (Skip to question 21) 1= No (Proceed to question 19) 4= We share a toilet with neighbours * 0=Yes 1= No	

19	How do you use the toilet at home?	1= Always * 0=Yes 1= No 2= Only sometimes * 0=Yes (Proceed to question 20 1= No (Skip to question 22) 3= I do not use a toilet * 0=Yes (Proceed to question 21) 1= No (Skip to question 22)	
20	From question 19, If you only use toilets only sometimes, Where do you ease yourself at other time	1= Lake * 0=Yes 1= No 2= In the river * 0=Yes 1= No 3= In the bushes * 0=Yes 1= No 4= Others, nameŒŒŒŒŒŒŒ ŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒ	
21	From question 18 and 19, If there is no toilet/don•t use toilet, Where do you ease yourself when at sch	1= Lake * 0=Yes 1= No 2= In the river * 0=Yes 1= No 3= In the bushes	

		* 0=Yes 1= No 4= Others, nameŒŒŒŒŒŒŒ ŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒ	

4.0. Medical information

22	Height (cm)	
23	Weight (Kg)	
24	Hb level (g/dL)	
25	Fecal occult blood test result * 0=Positive 1= Negative	

4.1. Which symptoms among these have you experienced in the past two weeks?

S/no.	Symptom (s)	Code*
26	Blood in stool	
27	Stomach pain	
28	Dysentery	
29	All of the above symptoms	

KEY: * 0 = No 1= Yes

4.2. Which symptoms among these have you experienced yesterday or today?

S/no.	Symptom(s)	Code*	* 0 = No 1 = Yes

30	Headache	
31	Vomiting	
32	Haematuria	
33	Vomiting blood	
34	Diarhoea	
35	Dizziness	
36	Difficult breathing	
37	Body swelling	
38	Body rashes	
39	Pain during micturition	
40	Others (mention)	

5. 0. Knowledge, attitude, preventive and risk practices relating to intestinal schistosomiasis

	Question	Code	Remarks
41	Have you ever heard of Intestinal schistosomiasis?	*0= Yes (Proceed to question 42) 1= No (Skip to question 48)	
42	If yes, what was the sourceof this information?	1=School 2=Home 3=Village dispensary 4=News media (Radio,	

		TV, News papers) 5=Others, nameŒŒŒ.. ŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒ	
43	If Yes (From question 41), what is th cause of intestinal schistosomiasis?	1= Worms 2= Mosquito bites 3= Swimming in the lake 4 = I don•t know 5=Swimming in the pond 6=Swimming in the river 7=Being bewitched 8= Others (name)ŒŒŒŒŒŒŒ	
44	Do you know the symptoms of intestinal schistosomiasis?	*0 = Yes (Proceed to question 45) 1= No (Skip to question 46)	
45	If Yes, what are the symptoms of intestinal schistosomiasis?	1=Haematuria 2=Painful during micturition 3=Stomach pain 4=Groin pain 5=Excessive thirsty 6=Ascites	
46	How is the disease intestinal schistosomiasis spread from one person to person?	1= Through skin penetration by the worm 2= Swimming/coming to contact with lake water infested with schistosoma cercaria	

		3= Others (name)ŒŒŒŒŒŒŒŒŒŒ	
47	Which are the most dangerous places for the transmission of intestinal schistosomiasis?	1= Lake 2= Paddy fields 3= River 4= All the above mentioned places 5= Others (name)ŒŒŒŒŒŒŒ.. 7= I don•t know	
48	Do you visit the lake?	0= Yes (Proceed to question 49) 1= No (Skip to question 56)	
49	If Yes, how many times do you visit the lake?	1= Everyday 2= 2€3 times a week 3= Once a week or less 4=Once amonth 5= Less tan once a month 6= I don•t visit the lake	
50	What do you normally do at the lake? nameŒ		
51	On average, how many times do you lake to do wahat you have mentioned	1 = I don•t visit the lake 2= 1-3 times a month 3= Once a week 4= 2-4 times a week	

		5= Everyday	
52	At what time do you visit the lake to do what you have mentioned abov?		
53	In which part of the lake do you normally do activities you have mentioned above?	1=Deep in the lake 2=Along the shoreline	
54	If you fish, how long do you spend in the lake fishing?	1= I don•t visit the lake at all 2= Less tan 30 minutes 3= Between 30 minutes to 1 hour 4= Between 1 to 2 hours 5= Between 2 to 4 hours 6= Between 4 to 6 hours 7= More tan 6 hours	
55	If you fish, which equipments do you use for fishing? Name		
56	Do you think Intestinal schistosomiasis treated?	1= Yes 2= No 3= I don•t know	
57	Have you ever been treated for intestinal schistosomiasis?	1= Yes (Proceed to question 58) 2= No (Skip to question 59) 3= I don•t know (Skip to question 59)	
58	If yes, which treatment did you get?	1= Took tablets 2= I gota n injection 3= I got an injection and took tablets	

		4 = I took herbs	
59	How do you regard intestinal schistosomiasis?	1= Is a dangerous disease 2= Is a chronic debilitating disease 3= Is a shameful disease 4= Is not a dangerous disease 5= Others (name)ŒŒŒŒŒŒŒŒŒ.	

60	Which ways can be used t protect oneself against intestinal schistosomiasis?	1= Avoid swimming/playing/ touching lake, river or pond water 1= Yes 2= No 3= I don•t know 2= Wearing protective gumboots when working on paddy fields 1= Yes 2= No 3= I don•t know 3= Getting medical checkup and appropriat treatment 1= Yes 2= No 3= I don•t know 4= Using toilets and avoiding defaecation on water source 1= Yes 2= No 3= I don•t know 5=Avoid playing with soil/sand 1= Yes 2= No 3= I don•t know 6=Washing hands before eating 1= Yes 2= No 3= I don•t know 7=Avoid drinking unboiled water 1= Yes 2= No 3= I don•t know 8=Washing fruits and vegetables before 1= Yes 2= No 3= I don•t know 9= Others (name)ŒŒŒŒŒŒŒŒŒŒ	

61	Do you know snails?	1= Yes 2= No	
62	If yes, where in your area can snails be found?(name)	1ŒŒŒŒŒŒŒŒŒŒŒŒ 2ŒŒŒŒŒŒŒŒŒŒŒŒ.	
63	Do snails have any effect on human health?	1= Yes 2= No	
64	If yes, which are those effects? Name	1ŒŒŒŒŒŒŒŒŒŒŒŒ... 2ŒŒŒŒŒŒŒŒŒŒŒŒ.	

6.0. Information on individual and community risk perception and health seeking behavior

65	Do you think there is intestinal schistosomia where you are living?	1=Yes 2=No	
66	If yes, which group of individuals do you think the most at risk group for getting intestin schistosomiasis infection?	1=Schoolchildren 2=Fishermen 3=Women 4=Old people 5=Paddy farmers	
67	Do you think you are at risk of getting infected w intestinal schistosomiasis?	1=Yes 2=No	
68	Which among these activities/behaviours can lea someone/community getting infected with intesti schistosomiasis?	1=Swimming in the lake 1=Yes 2=No 2=Fishing in the lake 1=Yes 2=No	

		3=Washing clothes in the lake or pond 1=Yes 2=No 4=Washing dishes in the lak 1=Yes 2=No 5=Drinking unboiled water 1=Yes 2=No 6=Hand shaking 1=Yes 2=No 7=Walking bare footed 1=Yes 2=No	
69	Have you ever had a person with intesti schistosomiasis in your household?	1=Yes 2=No	
70	If yes,what did you do with the patient?	1=He/she was taken to a dispensary 1=Yes 2=No 2=He/she was taken to traditional healer 1=Yes 2=No 3=He/she used herbs 1=Yes 2=No 4=He/she purchased drug	

		from a nearby drugs shop 1=Yes 2=No 5=He/she was taken church/mosque for prayers 1=Yes 2=No	
71	Have you experienced the following symptoms the past one week?	1=Haematuria 2=Painful micturition 3=Stomach pain 4=Vomiting blood 5=Blood in stool 6=Swelling ofthe feets	
72	What do you think is the proper treatment intestinal schistosomiasis?	1ŒŒŒŒŒŒŒŒŒŒŒŒ 2ŒŒŒŒŒŒŒŒŒŒŒŒ..	
73	Name other strategies that may be employed in fight against intestinal schistosomiasis	1ŒŒŒŒŒŒŒŒŒŒŒŒ 2ŒŒŒŒŒŒŒŒŒŒŒŒ..	

Appendix 5: Research Questionnaire of Swahili version

Fomu maalum ya kukusanyia taarifa za mshiriki katika utafiti wa kichocho na minyoo ya tumbo

1. Taarifa za mshiriki katika utafiti huu

Na.	Habari za mshiriki	Majibu
1	Herufi zajina la mkusanya taarifa	
2	Jina la kijiji	
3	Kipimo cha GPS	_____ / _____
4	Jina la kitongoji	
5	Tarehe ya ushiriki katika utafiti	
6	Jina la mshiriki	
7	Namba ya utambulisho ya mshiriki	

2. Taarifa za binafsi za mshiriki katika utafiti

S/N	Variable	Codes	Remarks
8	Jinsia	1= Mume 2=Mke	
9	Umri (Miaka)		
	Upo darasa la ngapi?		
10	Mzazi/Mlezi wako ana elimu gani?	1=Hajasoma 2=Elimu ya msingo	

		3=Elimu ya sekondari 4=Elimu ya chuo 5=Elimu ya chuo kikuu 6=Nyingine (taja) 7=Sijui	
11	Mzazi/Mlezi wako ana anafanya ka gani?	1=Mkulima/mfugaji 2=Mvuvi 3=Mfanyabishara 3=Mfanyakazi/mwajiriwa 4=Nyingine (taja) 5=Sijui	
12	Kwa muda gani umekuwa unais katika kijini hiki?	1= Nimezaliwa hapa ŒŒ(miaka) 2= Nimehamia hapaŒŒ(miaka)	

3.0. Taarifa za usafi

	Question	Code	Remarks
13	Shuleni kuna choo?	*0=Ndio (Nenda swali la 14) 1=Hapana (Nenda swali la 16)	
14	Kama ndio, Je, kwa namna ga unakitumia Choo shuleni?	1= Wakati wote ninapotaka kujisaidia	

		* 0=Ndiyo 1= Hapana 2= Baadhi ya wakati tu * 0=Ndiyo (Nenda Swali la 15) 1= Hapana (Nenda Swali la 17) 3= Huwa situmii choo kabisa * 0=Ndiyo (Nenda Swali la 16) 1= Hapana (Nenda 17)	
15	Kutoka swali la14, Kama huwa unajisaidia chooni baadhi ya wakati, Je, wakati mwingine huwa unajisaidia wapi?	1= Ziwani * 0=Ndiyo 1= Hapana 2= Mtoni * 0=Ndiyo 1= Hapana 3= Porini/Vichakani * 0=Ndiyo 1= Hapana 4= Kwengineko, tajaŒŒŒŒŒŒ ŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒ	
16	Kutoka swali la 13 na 14, Kama hakuna/ hutumii choo kabisa, Je huwa unajisaidia Wapi unapokuwa shuleni?	1= Ziwani * 0=Ndiyo 1= Hapana 2= Mtoni * 0=Ndiyo 1= Hapana 3= Porini/Vichakani * 0=Ndiyo 1= Hapana	

		4= Kwengineko, tajaŒŒŒŒŒŒ ŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒ	
17	Unatumia chanzo kipi cha maji unayotumia hapo unapoishi?	1= Maji ya bomba * 0=Ndiyo 1= Hapana 2= Ziwa * 0=Ndiyo 1= Hapana 3= Kisima kirefu kilichofunikwa * 0=Ndiyo 1= Hapana 4= Kisima kifupi kilichowazi * 0=Ndiyo 1= Hapana 5= Mto * 0=Ndiyo 1= Hapana	
18	Je, kwenye nyumba unayoishi unatumia aina gani ya choo?	1= Choo cha kisasa kinachotumia maji * 0=Ndiyo 1= Hapana 2= Choo cha shimo kwa ajili ya nyumba yako/yenu tu * 0=Ndiyo 1= Hapana 3= Hakuna choo * 0=Ndiyo (Nenda Swali la 21) 1= Hapana (Nenda Swali la 19	

		4= Ninatumia choo kimoja pamoja na majirani zetu * 0=Ndiyo 1= Hapana	
19	Je, kwa namna gani huwa unakitumia choo?	1= Wakati wote ninapotaka kujisaidia * 0=Ndiyo 1= Hapana 2= Baadhi ya wakati tu * 0=Ndiyo (Nenda Swali la 20) 1= Hapana (Nenda Swali la 22) 3= Huwa situmii choo kabisa * 0=Ndiyo (Nenda Swali la 21) 1= Hapana (Nenda 22)	
20	Kutoka swali la12, Kama huwa unajisaidia chooni baadhi ya wakati, Je, wakati mwingine huwa unajisaidia wapi?	1= Ziwani * 0=Ndiyo 1= Hapana 2= Mtoni * 0=Ndiyo 1= Hapana 3= Porini/Vichakani * 0=Ndiyo 1= Hapana 4= Kwengineko, tajaŒŒŒŒŒŒ	

		ŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒ	
21	Kutoka swali la 18 na 19, Kama hakuna/ hutumii choo kabisa, Je huwa unajisaidi Wapi?	1= Ziwani * 0=Ndiyo 1= Hapana 2= Mtoni * 0=Ndiyo 1= Hapana 3= Porini/Vichakani * 0=Ndiyo 1= Hapana 4= Kwengineko, tajaŒŒŒŒŒŒ ŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒ	

4.0. Taarifa za kitabibu

22	Urefu kwa kipimo cha sentimeta	
23	Uzito kwa kipimocha kilogram	
24	Kiwango cha damu	
25	Damu kwenye choo (kwa kipimo) * 0=Ndiyo 1= Hapana	

4.1. Je, ni dalili zipi umezipata katika wiki mbili zilizopita?

S/no.	Symptom (s)	Code*
26	Damu kwenye choo	
27	Maumivu ya tumbo	
28	Kuharisha damu	
29	Dalili zote hizo nimezipata (*)	

KEY: * 0 = Hapana 1= Ndiyo

4.2. Je, ni dalili zipi kati ya hizi umezipata jana au leo?

S/no.	Symptom(s)	Code*	* 0 = Hapana 1 = Ndiyo
30	Maumivu ya kichwa		
31	Kutapika		
32	Damu kwenye mkojo		
33	Kutapika damu		
34	Kuharisha		
35	Kizunguzungu		
36	Kushindwa kupumua		
37	Kuvimba mwili		
38	Vipele kwenye ngozi		
39	Maumivu wakati wa kukojoa		
40	Taja dalili zingine ulizopata Ambazo hazijaelezwa hapa		

5. 0. Uelewa, mtazamo, njia za kujikinga na tabia hatarishi zinazohusiana na maambukizi a ugonjwa wa kichocho

	Swali	Majibu	Jibu
41	Umeshawahi kusikia ugonjwa wa kichocho cha tumbo?	*0= Ndiyo (Nenda swali la 42) 1= Hapana (Nenda swali la 48)	
42	Kama ndio , je ulipata wapi taarifa kuhusiana na kichocho?	1=Shuleni 2=Nyumbani 3=Zahanati ya kijiji 4=Vyombo vya habari (Radio, Runinga, Magazeti) 5=Namna nyingineyo, tajaŒŒŒ ŒŒŒŒŒŒŒŒŒŒŒŒŒŒ	
43	Kama ndiyo (Kutoka swali la 41), nini kinasababisha kichocho cha tumbo?	1= Minyoo 2= Kung•atwa na mbu 3= Kuogelea ziwani 4 = Sifahamu 5=Kuogelea bwawani 6=Kuogelea mtoni 7=Kurogwa 8= NyingineŒŒŒŒŒŒŒŒ	
44	Je, unajua dalili zinazohusiana na ugonjwa	*0 = Ndiyo (Nenda swali la 45)	

	wa kichocho cha tumbo?	1= Hapana (Nenda swali la 46)	
45	Kama ndio, ni zipi dalili za kichocho cha Tumbo?	1=Kukojoa damu 2=Maumivu wakati wa kukojoa 3=Maumivu ya tumbo 4=Maumivu kwenye nyonga 5=Kusikia kiu mara kwa mara 6=Kujaa/kuvimba tumbo	
46	Je, ugonjwa wa kichocho cha tumbo unasambaaje tokakwa mtu mojaaliye na ugonjwa huo kwenda kwa mtu mwingine asiyekuwa na ugonjwa huo?	1= Kupitia kwenye ngozi baada minyoo kupenya. 2= Kuogelea/kugusa maji ya ziwa bwawa au mto yaliyo na vimelea vya ya kichocho 3= NyingineŒŒŒŒŒŒŒŒŒŒ	
47	Sehemu zipini hatari sana kwa maambukizi ya ugonjwa wa Kichocho cha tumbo?	e 1= Ziwani 2= Majarubani 3= Mtoni 4= Sehemu zote hapo juu 5= NyingineŒŒŒŒŒŒŒŒŒ 7= Sifahamu	
48	Je, huwa unakwenda ziwani?	0= Ndiyo (Nenda swali la 49) 1= Hapana (Nenda swali la 56)	

49	Kama ndiyo, ni mara ngapi unakwenda kuingia ziwani?	1= Kila siku 2= Mara 23 kwa wiki 3= Mara moja kwa wiki au chini ya hapo 4=Kwa mwezi mara moja 5= Chini yamwezi moja 6= Huwa siendi ziwani	
50	Kazi gani huwa unafanya ziwani? Taja		
51	Je, unaweza kukadiria ni mara ngapi unakwenda ziwani kufanya kazi ulizozitaja hapo juu?	1 = Huwa siendi ziwani 2= Mara 13 kwa mwezi 3= Mara moja kwa wiki 4= Mara 24 kwa wiki 5= Kila siku	
52	Je, ni wakati gani katika siku unakwend kufanya Kazi ulizotaja hapo juu? taja		
53	Je, ni sehemu gani ya ziwa huwa unakwend kufanya shughuli ulizotaja hapo juu?	1=Ndani ya ziwa 2=Ufukweni	
54	Kama ni mvuvi, je unaweza kukadiria unaotumia kuvua samaki kila unapokwenda ziwani?	1= Siendi kabisa ziwani 2= Chini ya dakika 30 3= Kati ya dakika 30 na saa 1	

		rs 5= Kati ya masaa 2 hadi 4 6= Kati ya masaa 4 hadi 6 7= Zaidi ya masaa 6	
55	Kama ni mvuvi, unatumia vifaa gani kuvulia samaki? Taja		
56	Je, unafikiri ugonjwa wa kichocho cha unatibika?	1= Ndiyo 2= Hapana 3= Sijui	
57	Je, umewahi kupata matibabu ya ugonjwa wa kichocho Cha tumbo?	1= Ndiyo (Nenda swali la 58) 2= Hapana (Nenda swali la 59) 3= Sijui (Nenda swali la 59)	
58	Kama ndiyo, ni aina gani ya matibabu uliopa?	1= Vidonge 2= Sindano 3= Zote 4 = Dawa za kienyeji	
59	Je, unauonaje ugonjwa wa kichocho cha tumbo?	1= Ugonjwa hatari sana 2= Ugonjwa sugu unadhoofisha 3= Ugonjwa wa aibu 4= Ugonjwa ambao si hatari 5= NyingineŒŒŒŒŒŒŒŒŒŒ	
60	Je, ninjia zipi unafikiri zinaweza kufaa kutumika kwa ajili ya kujikinga na ugonjwa wa kichocho cha tumbo?	1= Epuka kuoga/kucheza/kugus maji ya ziwani, mtoni na bwawani 1= Ndiyo 2= Hapana 3= Sijui 2= Kuvaa mabuti mare-f	

		wakati wa Kulima kwenye majaru 1= Ndiyo 2= Hapana 3= Sijui 3= Kupata uchunguzi wa kitabibu na matibabu sahihi 1= Ndiyo 2= Hapana 3= Sijui 4= Kutumia choo na kuepuka kujisaidia kwenye vyanzo vya maji 1= Ndiyo 2= Hapana 3= Sijui 5=Kuepuka kuchezea udongo/mchanga 1= Ndiyo 2= Hapana 3= Sijui 6=Kuosha mikono kabla ya kula 1= Ndiyo 2= Hapana 3=Sijui 7=Kuepeka kunywa maji yasiyochemshwa 1= Ndiyo 2= Hapana 3= Sijui 8=Kuosha matunda na mboga mboga kabla ya Kula. 1= Ndiyo 2= Hapana 3= Sijui	

		9= MengineŒŒŒŒŒŒŒŒŒ	
61	Je, unawafahamu kono kono?	1=Ndiyo 2=Hapana	
62	Kama ndiyo, ni wapi kono kono wanapatika eneo lako? (Taja)	1ŒŒŒŒŒŒŒŒŒŒ 2ŒŒŒŒŒŒŒŒŒŒ.	
63	Je, konokono wanaweza kuwa na madh kwa afyaya binadamu?	1=Ndiyo 2=Hapana	
64	Kama ndiyo,ni yapi madharahayo? Taja	1ŒŒŒŒŒŒŒŒŒŒ... 2ŒŒŒŒŒŒŒŒŒŒ.	

6.0. Information on individual and community risk perception and health seeking behaviour

65	Je, unafikiri katika eneo unaloishi ku kichocho cha tumbo?	1=Ndiyo 2=Hapana	
66	Kama ndiyo, unafikiri ni kundi gani wapo katika hatari zaidi ya kuambukizwa kichoc cha tumbo?	1=Watoto wa shule 2=Wavuvi 3=Wanawake wa nyumbani 4=Wazee 5=Wakulima wa mpunga	
67	Je, unafikiri wewe upo katika hatari y kuambikizwa ugonjwa wa kichocho ch tumbo?	1=Ndiyo 2=Hapaana	
68	Je, unafikiri ni shughuli au tabia gani kati	1=Kuogelea ziwani	

	hizi zinaweza kusababisha mtu au jam kuambukizwa ugonjwa wa kichocho cha tumbo?	* 0=Ndiyo 1= Hapana 2=Kuvua samaki ziwani * 0=Ndiyo 1= Hapana 3=Kufua ziwani au bwawani * 0=Ndiyo 1= Hapana 4=Kuosha vyombo ziwani * 0=Ndiyo 1= Hapana 5=Kunywa maji yasiyochemshwa * 0=Ndiyo 1= Hapana 6=Kusalimiana kwa mikono * 0=Ndiyo 1= Hapana 7=Kutembea pekupeku * 0=Ndiyo 1= Hapana	
69	Je, katika kaya unayoishi mmewahi kuwa na mgonjwa wa kichocho cha tumbo?	1=Ndiyo 2=Hapana	
70	Kama jibu ni ndiyo nini kilifanyika kumhudumia mgonjwa?	1=Alipelekwa katika zahanati * 0=Ndiyo 1= Hapana 2=Alipelekwa kwa mganga wa Jadi * 0=Ndiyo 1= Hapana 3=Alitumia dawa za mitishamba	

		* 0=Ndiyo 1= Hapana 4=Alinunua dawa kwenye duka la 5=Alipelekwa kanisani/Msikitini Kuombewa	
71	Je, Umeshasikia moja ya dalili hizi katil kipindi cha wiki moja iliyopita?	1=Kukojoa damu 2=Maumivu wakati wa kukojoa 3=Maumivu ya tumbo 4=Kutapika damu 5=Kutoa damu kwenye choo 6=Kujaa/kuvimba tumbo	
72	Unafikiri matibabu sahihi ya ugonjwa w kichocho cha tumbo ni yapi? taja	1ŒŒŒŒŒŒŒŒŒŒŒŒ 2ŒŒŒŒŒŒŒŒŒŒŒŒ..	
73	Taja mikakati mingine inayoweza kutumil kupambana na ugonjwa wa kichocho c tumbo (taja)	1ŒŒŒŒŒŒŒŒŒŒŒŒ 2ŒŒŒŒŒŒŒŒŒŒŒŒ..	

Appendix 6: Laboratory form – English version

Laboratory form

Participant's ID:..... Date of data collection:.....

Name of the participant:.....

Name of School:.....Grade.....

Participant's date of birth:.....Sex: Male ☐ Female ☐

Name of hamlet of residence:.....

Variable examined		Results	Comments
Weight		Kg	
Height		cm	
Schistosoma mansoni	Slide 1		
	Slide 2		
	Slide 3		
	Slide 4		
Hookworm egg count			
T. trichiura egg count			
Ascaris lumbricoides egg count			

Other parasites	1ŒŒŒŒŒŒŒŒŒŒŒŒ 2ŒŒŒŒŒŒŒŒŒŒŒŒ 3ŒŒŒŒŒŒŒŒŒŒŒŒ 4ŒŒŒŒŒŒŒŒŒŒŒŒ 5ŒŒŒŒŒŒŒŒŒŒŒ..	

Appendix 7: Laboratory form ƒ Swahili version

Fomu maalum ya kukusanyia taarifa za mshiriki katika utafiti wa kichocho na minyoo ya tumbo - Rorya

Namba ya Utambulisho ya Mshiriki:..ŒŒŒ.. Tarehe ya ukusanyaji tarifa:ŒŒŒŒŒŒŒŒ.

Jina la Mshiriki:ŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒ

Jina la shule:ŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒDarasaŒŒŒŒŒŒŒŒ

Tarehe ya kuzaliwa ya Mshiriki:ŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒŒJinsia: Mu☐ Mke ☐

Kitongoji Unachoishi:ŒŒŒŒŒŒŒŒŒŒ.

Variable examined		Results	Comments
Uzito kwa kipimo cha kilogram		Kg	
Urefu kwa kipimo cha sentimeta		Sm	
Schistosoma mansoni	Slide 1		
	Slide 2		
	Slide 3		
	Slide 4		
Hookworm egg count			
T. trichiura egg count			
Ascaris lumbricoides egg count			
Wadudu wengine		1ŒŒŒŒŒŒŒŒŒŒŒŒŒŒ 2ŒŒŒŒŒŒŒŒŒŒŒŒŒŒ 3ŒŒŒŒŒŒŒŒŒŒŒŒŒŒ 4ŒŒŒŒŒŒŒŒŒŒŒŒŒŒ 5ŒŒŒŒŒŒŒŒŒŒŒŒ..	