PREVALENCE, INTENSITY AND THE FACTORS ASSOCIATED WITH INTESTINAL SCHISTOSOMIASIS IN PRESCHOOL CHILDREN IN UKEREWE ISLAND, MWANZA REGION TANZANIA

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Prevalence intensity and the factors associated with intestinal schistosomiasis in preschool children in Ukerewe island Mwanza region Tanzania

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DECLARATION

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

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DEDICATION

This work is dedicated to my late father Eng. Domistocles John Ruganuza, my mother Valentina Maruka for initiating and instilling in me the love of education. My lovely wife Dr. Illuminata Machumi and my sons Vincent, Ryan and Fabian for being patient with me the whole time I was busy studying.

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LIST OF ABBREVIATIONS

AOR	Adjusted Odds Ratio
BMC	Bugando Medical center
CBRD	Center for Biotechnology Research and Development
CCA	Circulating Cathodic Antigen
CUHAS	Catholic University of Health and allied sciences
ERC	Ethics review committee
ELISA	Enzyme Linked Immunosorbent Assay
GPS	Glopal Position System
IRB	Institutional review board
ITROMID	Institute of Tropical Medicine and Infectious Diseases
JKUAT	Jomo Kenyatta University of Agriculture and Technology
KEMRI	Kenya Medical Research Institute
OR	Odds ratio
RSA	Republic of South Africa
USA	United States of America
WA	Washington
WHO	World Health Organization

ABSTRACT

Recent evidence indicates that preschool children (PSC) living in *S. mansoni* highly endemic areas are at similar risk of schistosomiasis infection and morbidity as their school aged counterparts. Recognizing this fact, the World Health Organization (WHO) is considering including this age group in control programs using mass drug administration (MDA), in the highly endemic areas. However, detailed epidemiological information on *S. mansoni* infection among PSC is lacking for many endemic areas, including in Tanzania. This study was conducted to determine the prevalence and intesnsity of *S. mansoni* infection among PSC in Lake Victoria's Ukerewe Island, in North-Western Tanzania, and the factors associated with infection in this age group.This was a cross-sectional study involving 400 PSC aged 1- 6 years of age. The Kato-Katz (K-K) technique and the point of care circulating cathodic antigen (CCA) immunodiagnostic test were used to diagnose *S. mansoni* infection in stool and urine samples, respectively, and a pre-tested questionnaire was used to collect demographic data and water contact behaviour of the children through their parents/guardians. GPS data of the households of study participants and water contact points nearest to their homesteads was obtained. Data collected was entered into data collection forms, notebooks, and then transferred into the Microsoft Excel software for consistency data checks and data cleaning. Analysis was done using STATA 13 and ArcGIS ArcMap 10.2.2. Chi squared test for difference in frequencies were performed. Potential associations were assessed at a bivariate level; then, factors with *P*-value <0.2 were entered into multivariate model. Sex and age group term were entered as *a priori* into the multivariate model. Stepwise backward logistic regression was used to determine whether these variables were independent factors of *S. mansoni*. Independent risk factors of faecal egg counts were identified in a linear regression model using a log-transformed egg per gram of faeces (epg) as outcomes variable and social demographic factors as explanatory variables. The odd ratios of each of the risk factors associated with faecal egg counts were obtained by taking the antilogarithm of the regression coefficient.

Based on the K-K technique, 44.4% (95% CI: 39.4-49.4) preschool children were infected with *S. mansoni* and the overall geometric mean eggs per gram of faeces (GM-epg) was 110.6 epg with 38.2% and 14.7% having moderate and heavy intensity infections respectively. Based on the CCA, 80.1%, (95% CI: 76.0-84.0) were infected if a trace was considered positive, and 45.9%, (95% CI: 40.9-50.9), were infected if a trace was considered negative. Reported history of lake visit (AOR= 2.31, 95% CI 1.06 - 5.01, P<0.03) and the proximity to the lake shore (<500m) (AOR= 2.09, 95% CI: 1.05-4.14, P<0.03) were significantly associated with *S. mansoni* infection. Reported lake visit frequency (4 -7days/week) was associated with heavy intensities of *S. mansoni* infection (P<0.00).The prevalence of *S. mansoni* infection in the study population using K-K and CCA trace is negative was moderate. The frequency of lake visits, the proximity to the lake shore were associated with the infection of *S. mansoni* and its intensity. These findings call for the need to include the PSC in MDA programs, public health education and provision of safe water for bathing.

CHAPTER ONE

INTRODUCTION

1.1 Schistosomiasis

The WHO estimates that 207 million people are affected with schistosomiasis worldwide, with another 779 million living under the risk of infection (Gryseels, Polman, Clerinx, & Kestens, 2006; Hotez *et al.,* 2007). Over the years the distribution of schistosomiasis has changed from being the most widespread parasitic infection in the world in the year 1985 to being confined to sub-Saharan Africa where it accounts for 90% of the global cases (Hotez *et al*., 2007).

In sub-Saharan Africa, control efforts against schistosomiasis are either non-existent or unsustainable. Control measures elsewhere in the world have been largely successful, with the elimination of the disease and control targets being reached (World Health Organization, 2013). Consequently, the fight against schistosomiasis remains a priority in sub-Saharan Africa. Considered a neglected tropical disease, schistosomiasis remains a major public health problem, especially in children, who suffer the brunt of these infections.

Schistosomiasis is a snail-transmitted water-associated helminth infection and children are the most vulnerable and the most at risk of acquiring it. It is a chronic infection rarely causing mortality in affected populations, yet they are associated with ill-health and other debilitating conditions such as anaemia, malnutrition, stunted growth and impaired cognitive development (King & Dangerfield-Cha, 2008).

1.2 Control strategies for schistosomiasis

Currently, the main control strategy against schistosomiasis is chemotherapy targeting, primarily, school children and, sometimes, the entire community (World Health

Organization, 2013). Other available control strategies include improved water sanitation and hygiene, health education and snail control.

In Tanzania, the National Programme for the control of schistosomiasis was established in 2004.These control efforts use mass chemotherapy as a main strategy and they usually target school children (6-15 year-olds)(Fenwick, 2006).

Although chemotherapy of schistosomiasis is effective, re-infection rapidly occurs, even after a successful intervention (Utzinger *et al.,* 2009). Re-infection partly, occurs because treated infected but uncured individuals continue to contaminate the environment, thus maintaining transmission; and partly, because some infected individuals in the community are not targeted by disease control programs, and therefore, serve as “reservoirs” for new infections or re-infections (Satayathum, Muchiri, Ouma, Whalen, & King, 2006)**.** Effective control of schistosomiasis can however, be achieved if all vulnerable and most at risk or infected population groups are targeted for intervention.

For many years, it was assumed that the treatment of school age children was sufficient for effective control of schistosomiasis. However, recent findings have reported some specific groups in a community that are ordinarily not targeted for intervention such as preschool children are also affected by schistosomiasis (Coulibaly, N'Gbesso, N'Guessan, *et al*., 2013; Dabo, Badawi, Bary, & Doumbo, 2011; Sousa-Figueiredo *et al.,* 2010; Verani *et al.*, 2011)**.** It is possible that these may also, serve as “reservoirs” for new infections or re-infections. If preschool children are commonly infected, then they could also benefit from intervention measures such as chemotherapy.

Yet, for many endemic areas, relatively very little is known about the magnitude of schistosomiasis in preschool children, and to what extent this population group contributes to the maintenance of the schistosomiasis transmission in endemic localities.

For an effective disease control, the prevalence and intensity of infections needs to be established in the whole spectrum of the population age groups.

In Tanzania, there are essentially two species of human schistosomes namely *Schistosoma haematobium* and *S. mansoni*, causing the urogenital and intestinal forms of the disease respectively (Mazigo *et al.,* 2012).*S. mansoni* is present and endemic in Ukerewe Island (Ajanga et al., 2006; El Scheich et al., 2012; Malenganisho et al., 2008). However, there are no reports indicating presence of *S. haematobium* on the Island.

The proposed study investigated *S. mansoni* in preschool children in the Ukerewe Island located in Lake Victoria, in Mwanza Region, in north-western Tanzania. The island is essentially inhabited by fishermen and but subsistence farming is also, a major activity. The study aims at determining the prevalence and intensity of intestinal schistosomiasis in preschool children, and factors associated with its presence in this population group.

1.3 Statement of the problem

Schistosomiasis remains endemic in most parts of the Lake Victoria region of North-Western Tanzania, and is a major cause of morbidity among school children, and some of the consequences attributed to the infection include poor school attendance, impaired cognitive development and malnutrition (King & Dangerfield-Cha, 2008).There is scanty information on the prevalence intensity and factors associated with schistosomiasis in preschool children, who are not ordinarily included in epidemiological studies or control programs.

1.4 Study justification

Very little is known about the prevalence of intestinal schistosomiasis and factors associated with infection in preschool children in Ukerewe Island. This information is necessary for an effective implementation of control measures. The findings of this study will help the local schistosomiasis control authorities in understanding the epidemiological situation of schistosomiasis in this locality considering that under the current guidelines the very young children should be treated in health facilities as part of the national programs (World Health Organization, 2013).

1.5 Research questions

a) What is the prevalence of *Schistosoma mansoni* infections in preschool children in, Ukerewe Island?
b) What are the intensity profiles of *S. mansoni* in preschool children on the Island?
c) What are the factors associated with infection of *S. mansoni* in preschool children (1-6 years old) in the area?

1.6 Objectives

1.6.1 General Objective

To determine the prevalence, the intensity of infection and the factors associated with *Schistosoma mansoni* in preschool children in Ukerewe Island.

1.6.2 Specific objectives

1. To determine the prevalence of *S. mansoni* in preschool children living in Ukerewe Island, Mwanza Region, Tanzania
2. To determine the intensity profile of *S. mansoni* in preschool children in Ukerewe Island.
3. To determine factors associated with *S. mansoni* infection among preschool children (1-6 years old) on the Island.

CHAPTER TWO

LITERATURE REVIEW

2.1 Schistosome biology

Schistosomiasis is caused by digenetic trematodes of the genus Schistosoma (Rollinson & Simpson, 1987). There are three main species affecting man: *Schistosoma mansoni*, *S. haematobium* and *S. japonicum*. Two more species which are more localised geographically are *S. mekongi* and *S. intercalatum*. Schistosomes have a complex lifecycle which alternates between humans and aquatic snail. The adult worms live in the mesenteric venules of the definitive host. Females deposit eggs in the portal and perivesical systems .The eggs move towards the lumen of the intestine (*S. japonicum* and S. *mansoni*) or the lumen of the bladder and ureters (*S. haematobium*). The parasite eggs are excreted in urine and faeces. Under optimal conditions, the eggs hatch and release miracidia which swim and penetrate specific snail intermediate hosts. In the snail the miracidia, develop through two sporocyst generations to release cercaria.

The cercariae penetrate the skin the definitive host and shed their forked tail becoming schistosomula, enter the circulatory system and migrate to the liver and eventually to the bladder or mesenteries where pairing of male and female schistosomes take place. These pairs migrate to the preferred site of egg deposition.

2.2 Control of schistosomiasis

The current strategy of control of schistosomiasis is chemotherapy with Praziquantel in schistosomiasis endemic area which targets school aged children (6-15 years old) and adults (>15 years) especially in high risk occupations. The aim is to primarily target those who harbour the highest infection intensities (World Health Organization, 2013). For this purpose the use of school based programs as a strategy is used to deliver mass chemotherapy intervention to school going children.

2.3 *S. mansoni* infection in School children

Schistosomiasis has been studied extensively in school children, and several studies have reported a high prevalence and intensity of infection in the school children aged 6-15 years. For instance, in Kenya, Odiere and others observed that in Mbita and the nearby islands in Lake Victoria, in western Kenya, prevalence of *S. mansoni* in school children was 60.5%, with peak prevalence occurring in children aged 11-16 years (Odiere *et al.*, 2012). School children also, suffer most from morbidity associated with *S. mansoni* and consequences of infection include anemia, growth stunting, impaired cognitive development, increased susceptibility to coinfection decreased quality of life, exercise intolerance, portal hypertension and liver failure (King & Dangerfield-Cha, 2008).These are inherently absent or difficult to evaluate when it comes to preschool children where symptoms are generalised and nonspecific (Samuels *et al.*, 2012).

School children have been at the focus of schistosomiasis control by mass chemotherapy(World Health Organization, 2013), and evaluation of school based programs have shown that mass drug administration programs have been largely successful in reducing prevalence and intensity of infection (Kabatereine et al., 2007).

2.4 *Schistosoma mansoni* infection in preschool children

Until recently the epidemiology and control of schistosomiasis focused primarily on infections in school aged children and to a lesser extent on adults (Ekpo, Oluwole, et al., 2012) and underlined the importance of the selected age group as the target population. The strategy has left preschool children overlooked .This was based on previous assumptions that water contact levels of preschool children were insufficiently low for a substantial risk of infection (Stothard & Gabrielli, 2007) as infection was thought to be a function of mobility and confidence swimming in water. It was pointed out that the exposure of infants and preschool children to cercariae contaminated water was rather passive (ie the children are exposed second-hand to water for example when bathing) than active (when children play in cercariae contaminated water in a pond, river or lake) (Rollinson et al., 2012; Stothard & Gabrielli, 2007).

In a study done in Uganda by Sousa Figuiredo et al., 2010 two surveys were done on preschool children one in Lake Albert and the other in Lake Victoria in Uganda, using three diagnostic methods namely Kato-Katz, soluble egg antigen-enzyme linked immunosorbent (SEA-ELISA) assay, and urine circulating cathodic antigen (CCA), infection prevalence was 44.3% in Lake Albert and 16% in Lake Victoria (Sousa-Figueiredo *et al.*, 2010).

A study done in Usoma Kenya on *S. mansoni* in preschool and school aged children has shown that the prevalence of *S. mansoni* infection in preschool children was 37% and the prevalence rate in the 1 year olds alone in this locality was 14% (Verani et al., 2011). However, in general intensity of infection in the age group, was much lower than for the school going children.

In one locality in Cameroon where both *S. haematobium* and *S. mansoni* were studied in preschool children, the prevalence of *S. mansoni* was 23% using quadruplicate Kato-Katz method (Coulibaly, N'Gbesso, N'Guessan, et al., 2013). With the CCA test, on the other hand, 92% of duplicate CCA samples were considered positive for this group.

Several other studies have been conducted in preschool children infected with *S. haematobium* in Ghana, Mali, Niger, Nigeria and Zimbabwe, and the prevalence ranged between 18-86% (Bosompem *et al.*, 2004; Dabo *et al.*, 2011; Ekpo, Alabi, Oluwole, & Sam-Wobo, 2012; Ekpo, Laja-Deile, Oluwole, Sam-Wobo, & Mafiana, 2010; Garba *et al.*, 2010; Mafiana, Ekpo, & Ojo, 2003; Mutapi *et al.*, 2011; Opara, Udoidung, & Ukpong, 2007; Sousa-Figueiredo *et al.*, 2010; Verani *et al.*, 2011).

2.5 Factors associated with exposure to S. mansoni infection in preschool children

Schistosomiasis infection in adults is innately connected with occupational activities such as fishing, while infection in school-aged children is associated with recreational activities such as swimming, playing, and their involvement in domestic chores (Stothard & Gabrielli, 2007). Very few studies have investigated factors that are associated with exposure of preschoolers to schistosomiasis, and those that have been undertake relied on administering questionnaires and focused group discussions with parents/guardians, caregivers and older school aged children (Bosompem *et al.*, 2004; Mafiana *et al.,* 2003). In these studies, mothers and caregivers admitted to taking their infants and preschool children to streams infested with schistosome cercariae for bathing, and older preschool children visited water bodies for washing their clothes, bathing, fetching water and swimming (Ekpo *et al.*, 2010). In a study done in Cameroon children older than 24 months have been found to have a 8.8-fold risk of being infected with *S. mansoni* than their counterparts who are younger than 24 months, and children who were involved in their mothers' livelihood activities have a 2.3-fold higher odds to be infected with *S. mansoni* (Coulibaly, N'Gbesso, N'Guessan, *et al.*, 2013)

2.6 Prevalence and Intensity of infection and diagnostic methods

The assessment of prevalence and intensity of infection in preschool children remains a challenge as the Kato-Katz technique is known to be less sensitive when applied in low intensity infection areas (Berhe *et al*., 2004).Fortunately a newer more sensitive antigen detection method has recently come into use,the *S. mansoni* urine Circulating Cathodic Antigen (CCA). The urine CCA test was developed for qualitative presumptive diagnosis of Schistosmiasis, more specifically *S. mansoni*. The test has harnessed the fact that *S. mansoni* parasite regurgitates at regular intervals undigested particulate as well as parasite gut undigested glycoproteins. One of the major regurgitated antigens is CCA or Antigen M which was demonstrable in serum, urine and mothers' milk of infected humans (de Jonge, Polderman, Hilberath, Krijger, & Deelder, 1990). Although parasite eggs also release CCA this is in minute quantities, the major source of CCA is live adult worms.(Deelder *et al.,* 1994). A good correlation has been demonstrated between *S. mansoni* fecal egg counts and Urine CCA levels (Polman, Engels, Fathers, Deelder, & Gryseels, 1998). For endemic areas single urine CCA demonstrates closely the true prevalence predicted by models based on multiple egg count determinations.(De Clercq *et al.,* 1997)

Many studies have been done to evaluate the use of CCA in *S. mansoni* endemic areas. For instance one study where intestinal schistosomiasis in mothers and their children (aged less than 3 years) was studied using both the Kato-Katz test and the recently developed CCA test, infections in children were found to be predominantly light (Odogwu *et al.*, 2006). This study also showed that there was disparity in results obtained in mother-child pairs where some mothers were found negative by CCA while their children were negative by Kato-Katz but positive by CCA (meaning that CCA had not been passed from mother to child through breastfeeding, and certainly, not congenitally) which led to the hypothesis that young children probably harbour infections that are prepatent where immature worm pairs were yet to commence egg deposition.

In another study in which Kato-Katz method, serum egg antigen-ELISA and the urine CCA were used to diagnose *S. mansoni* in children between 5 months and 5 years, it was observed that the age at which the children first became positive was 9 months by when a double smear of Kato-Katz procedure was used, 6 months when the CCA test was used, and 6 months when serum egg antigen-ELISA was used (Stothard *et al.*, 2011). Both Kato-Katz and CCA detection methods found predominantly light infections with a mean intensity of 89 eggs per gram Kato-Katz method. Prevalence by Double smear Kato-Katz, Urine CCA and Serum Egg Antigen was found to be 21.9%, 42.6% and 45.9% respectively. This study has shown that direct detection of eggs in stool have a temporal lag when compared with antibody and antigen methods. They further show that children who are infected although probably harbour light infections, may wait for up to five years before they receive Praziquantel under the current control strategy.

With regards to sensitivity, a recent study has showed that a single point of care CCA cassette test is more sensitive than multiple Kato-Katz thick smears for the diagnosis of *S. mansoni* in preschool children before and after treatment with Praziquantel.(Coulibaly, N'Gbesso, Knopp, *et al*., 2013).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Area

Ukerewe Island is located in Ukerewe district in Mwanza Region, North-Western Tanzania. It is the biggest island in Lake Victoria and is located North of Nyamagana, Ilemela and Magu and west of Bunda district. In the 2002 census there were 261,944 people living in Ukerewe district. The study sites were Musozi village which has 7 sub-villages namely Bukindo-Nkokolo, Haluseni, Hamurumo, Gallu, Buhamba, Nakabungo and Halweya in Bukindo ward Ukerewe District. Musozi village is a peninsular on the North eastern part of Nansio (the Main Island) whose inhabitants are engaged in fishing and subsistence farming.

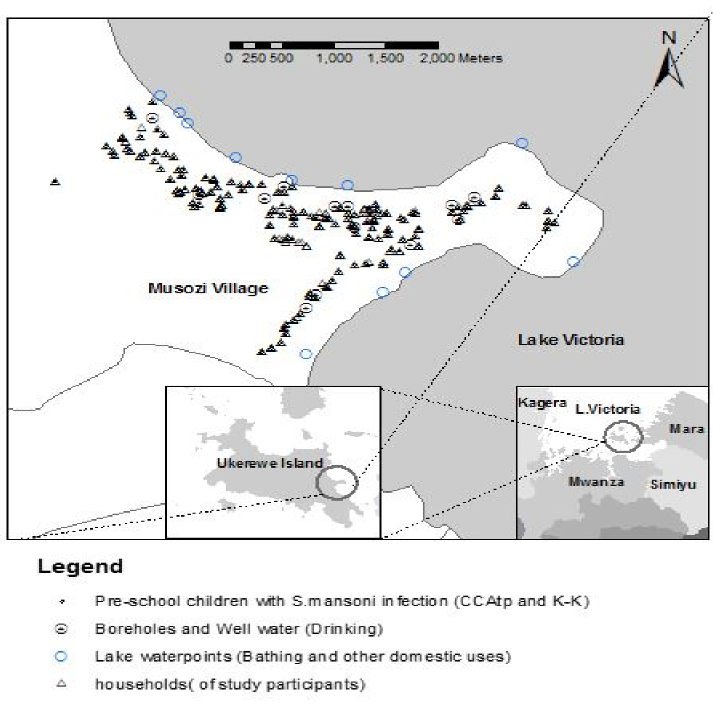

Figure 3.1: The map of Musozi village showing household of *S. mansoni* infected and uninfected children boreholes and water contact points

3.2 Study design

This was a cross sectional study that was undertaken between the period of October 2013 and April 2014 in Musozi village (peninsular) North Eastern side of Nansio, Ukerewe Island.

An interview with study participants parents and guardian was conducted where a questionnaire was used to capture demographic data and factors associated with infection. For each child enrolled one stool and urine sample was collected. Stool and Urine was analysed by Kato-Katz method and Circulating Cathodic Antigen (CCA) by urine CCA cassettes (Rapid Medical Diagnostics, Pretoria, RSA) respectively.

3.3 Study Population

The study population comprised of preschool children aged between 1 year and below 7 years, living in Musozi village Ukerewe Island. It is estimated that there are 712 children between the ages of 1 to 7 years in Musozi village.

3.4 Inclusion criteria

Children were enrolled in the study if

1. Their age was between1 years and 7 years

2. The parents/guardian provide written consent for children

3. They have lived in study area for at least 6 months at the time the study commences.

4. They have not received Praziquantel in the previous one year.

3.5 Exclusion criteria

1. If the child was weak, had fever or cough.

3.6 Sample size determination

The sample size was calculated using the Kish Leslie formula (Fisher, 1966) based on prevalence of *S. mansoni* preschool children in lake Albert, Uganda.which was 47.5% (Stothard et al., 2011)

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

Where P = Prevalence of infection (Schistosomiasis)

Z= Z score of confidence interval

d= Tolerable error (absolute precision) 5%

$$\text{Sample size } N = \frac{1.96 \times 1.96 \times 0.475\,(1-0.475)}{0.05 \times 0.05}$$

N=383

The minimum sample size for this study was 383 preschool children

3.7 Recruitment strategy

A village meeting was held with all the villagers explaining the objectives, risks and benefits of the study in the language understood by the villagers. Villagers were asked to bring their children to designated sub village centres on dates that were planned by the research team. The research team visited each of the 7 sub villages for 2 days for each sub village where children were recruited then their parents were asked for consent for their children's participation in the study before screening of inclusion criteria.

3.8 Sampling procedure

For children who met the inclusion criteria a systematic sampling procedure was used. The sampling interval was 1.86 which was approximately 2 that is 712 (target population) divided by 383 (sample size). Two out of every three children who met the inclusion criteria were enrolled into the study until the sample size was achieved.

3.9 Stool sample collection and laboratory examination for helminths infection

Children were asked to defecate on a toilet paper put on the ground from which, a small amount was put into a labelled container. The samples were processed within an hour after collection by experienced technicians at the field laboratory. Two Kato- Katz cellophane thick faecal samples were prepared on a glass microscope slide according to the described procedure by Katz and others and WHO (Katz, Chaves, & Pellegring, 1972; WHO, 1991). The smears were prepared and examined for hookworm ova under a microscope within 30-60 minutes after preparation. They were left to clear for 24hrs at room temperature and were re-examined for ova of *S. mansoni* where counts were made. Any other intestinal helminths ova were recorded as positive or negative. Egg counts for *S. mansoni* duplicate slide were averaged and then multiplied by 24 (factor used for 41.7 g templates to obtain egg per gram of faeces). For quality control 10% of slides were re-examined by an experienced parasitologist, blind of the results of the first reader.

3.10 Determination of prevalence of *S. mansoni* by Point of care circulating cathodic antigen cassette test

From each child that is recruited as a study participant a urine sample was collected in a urine container from which a 50 µl aliquot for testing the presence of *Schistosoma mansoni* circulating cathodic antigen with a commercially available immuno-chromatographic dipstick (Rapid Medical Diagnostics, Pretoria, RSA), a rapid diagnostic test for intestinal schistosomiasis .The test was recorded positive if the control band and the test band react and negative if the control band only react , if the test reacted but the control band did not react the test was considered invalid. Two positivity criteria were used one where trace is considered positive and the other where trace is considered negative (Figure 3.2).

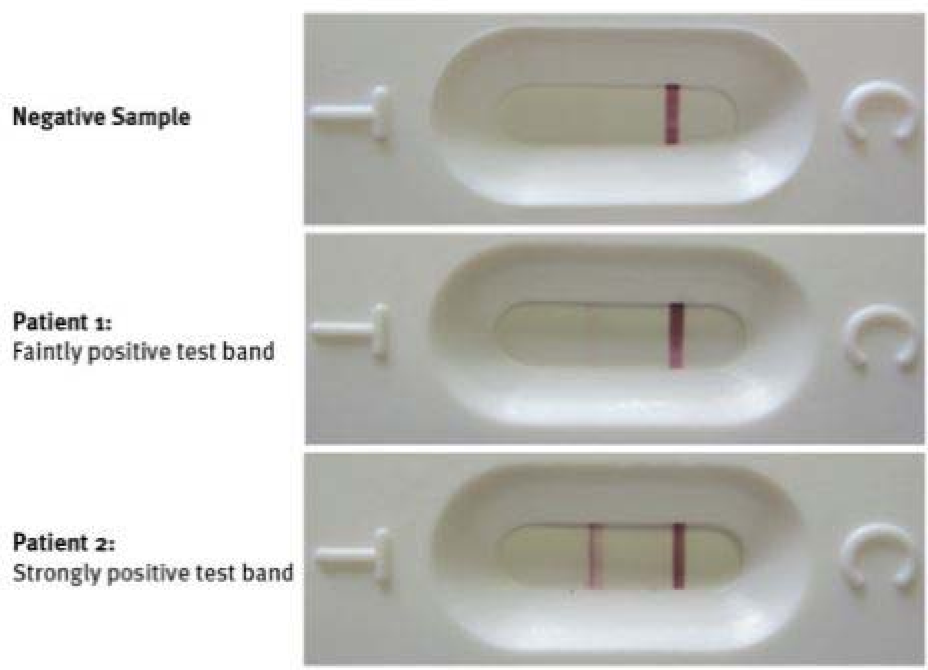

Figure 3.2: Picture of CCA reaction showing negative sample, trace (faint positive) and strong positive.

3.11 Determination of factors associated with *S. mansoni* infection

Data on factors that were associated with infection with *S. mansoni* in preschool children was collected by a structured questionnaire (Appendix I) that asked on socioeconomic factors such as marital status, literacy levels of the caregivers, occupation, availability of clean water while data about distance from the lake, proximity to other water resources by Global positioning system (GPS) data, sanitation (presence of toilets), sanitation practices. Data on mode of exposure was obtained by asking in the previous week where had the child bathed was it at the lake or at home / any other water body assuming that the child bathes once in a day. Frequency of exposure was determined by asking the caretaker how many times the child had been to the lake with or without a caregiver (mother, guardian, sibling)/other water body in the previous week, what was the principal aim of the visit to the lake (swimming, bathing, washing utensils, fetching water buying fish or others)

3.12 Data Management and statistical analysis

The data entered and stored in Microsoft Excel 2007 was checked for entry errors and was analysed using statistical tools available in the STATA version 12 software (STATA Corp, College Station, Texas, USA). GPS data was analysed by using ArcGIS ArcMap 10.2.2 were a map of the study area was generated and distance obtained to the nearest lake water collection was obtained. The age variable was described as mean ± standard deviation and categorized into age groups: 1-<2, 2-<3, 3-<4, 4-<5, 5-<6, 6-<7 years. Binary variables were compared using the Chi-square test (χ^2) or the Fisher exact test, where appropriate. The intensity of infection was categorized according to WHO criteria as ≤99 epg (light), 100-399 epg (moderate), or ≥400 epg (heavy) (WHO, 2002). Prevalence of infection was of <10% is low, ≥10 but <50% is moderate prevalence and >50% high prevalence. ANOVA or t-tests were used to test for the difference in mean egg counts for *S. mansoni* between sex and age-groups.

Demographic and socio-economic variables were assessed using logistic regression. The potential associations were first assessed at a bivariate level; then, factors with a *P*-value <0.2 were entered into the multivariate model. Sex and age group term were entered as *a priori* into the multivariate model. Stepwise backward logistic regression was used to determine whether these variables were independent factors of *S. mansoni*. Independent risk factors of faecal egg counts were identified in a linear regression model using a log-transformed egg per gram of faeces (epg) as outcomes variable and social demographic factors as explanatory variables. The odd ratios of each of the risk factors associated with faecal egg counts were obtained by taking the antilogarithm of the regression coefficient.

3.13 Treatment of schistosomiasis

Children who were found to be infected with *S. mansoni* were treated with Praziquantel, dose 40mg/kg and Albendazole at 200 mg respectively for coincidental soil transmitted helminths. Before the drugs were administered porridge and sweet potatoes were prepared to reduce the nauseating effect of Praziquantel.

3.14 Ethical considerations

Study Approvals

Ethical approval was obtained from both KEMRI ethics review committee (ERC) and CUHAS/BMC and Institutional review board for all aspects in this study and obtained clearance number SSC 2739 and BREC 035/2013 respectively (Appendix VI).

Community engagement

Approval was sought from the District Medical Officer of Ukerewe District Council. This study was conducted in Musozi village, Ukerewe district Mwanza region among children aged 1 to <7 years.

Informed consent

Prior to recruitment and selection the Principal investigator talked to the village administration and parents in a village meeting to explain the purpose of the study. The study was explained in Swahili a language understood by the local residents. Those who did not attend the village meeting follow up was made through village leaders.

Participation was voluntary and participants could withdraw at any time without penalty. All children were given a written consent form (Appendix III and IV) for their parents to sign.

Only those children whose parents gave a written consent were enrolled in the study. This study involved no or minimal physical risk associated with method of stool and urine sample collection. Children who were found positive for *S. mansoni* were treated with Praziquantel at standard dose of 40mg/kg, any child that were found with geohelminths were treated with Albendazole at dose of 400mg. Albendazole and Praziquantel are safe and pose minimal risk as they are known to be safe for use in the age group. The precaution of feeding the children before treating them with Praziquantel was done. Any adverse events related to treatment, however were reported immediately to the KEMRI's ERC and CUHAS/BMC IRB. If other medical conditions are suspected, the participant were referred to the nearest health center. To ensure confidentiality each participant were given a personal identification number and all future references were referred by this number .All consent forms, data and information were stored under lock and key and data entered into a computer was protected by a password. Each participant received the results of urine and faecal testing/examination. When the study finished the outcome of the study was disseminated to the local community and the District council health management team.

CHAPTER FOUR

RESULTS

4.1 Summary of study participation.

A total of 400 children were enrolled into the study after meeting the inclusion criteria and consenting to participate in the study. The structured questionnaire was administered to all 400 children. They were also asked to bring samples of stool and urine within 4 hours.17 children did not bring or brought insufficient amount of stool and 14 children didn't bring urine samples. Therefore 383 stool samples were processed by Kato-Katz and 386 urines samples were tested for CCA. Finally 375 children had complete data for both Kato-Katz and CCA where 11 CCA results had missing Kato-Katz results and 8 Kato-Katz had missing CCA results.

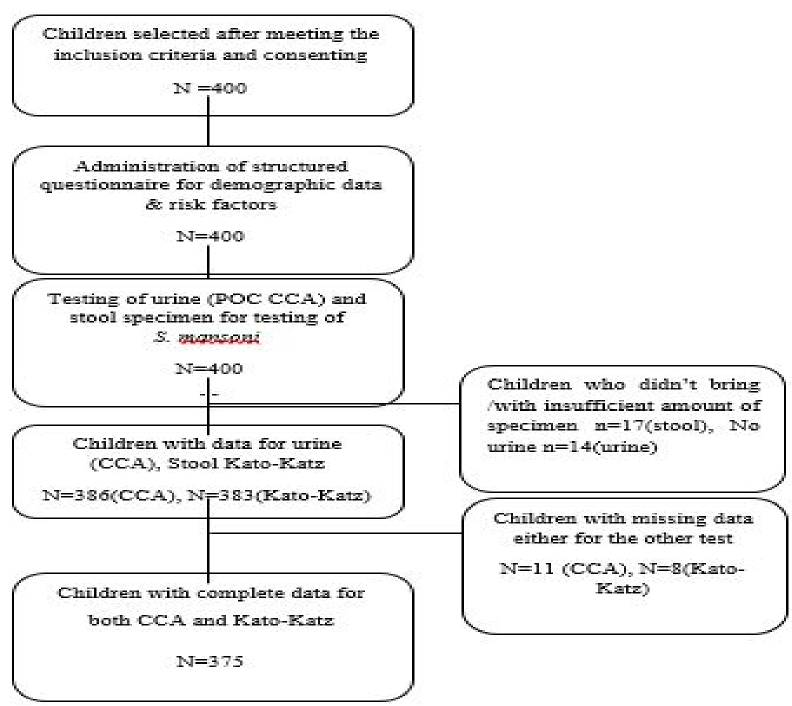

Figure 4.1: Summary of study participation of preschool children

4.2 Demographic characteristics of the study population

A total of 400 children aged between 1 and 6 years from 7 subvillages of Musozi village Ukerewe district who had given consent for participation, were enrolled in the study. The mean age of children was 45 ± 1.926 months. The male and female ratio was roughly 1:1. (table 4.1).

Table 4.1: Demographic characteristic of the study population

Age (years)	Males	%	Females	%
1-<2	26	12.81	37	18.78
2-<3	36	17.73	41	20.81
3-<4	42	20.69	28	14.21
4-<5	30	14.78	31	15.74
5-<6	39	19.21	35	17.77
6-<7	30	14.78	25	12.69
Total	203		197	

4.3 Prevalence of *S. mansoni* in preschool children in Musozi village Ukerewe district.

4.3.1 Prevalence of *S. mansoni* by Kato-Katz

A total of 383 children were examined for intestinal schistosomiasis by the use of Kato-Katz method, 170 out of 383 were found to be positive. The prevalence of schistosomiasis was 44.9%, (95% CI: 39.8-49.9).

4.3.2 Prevalence of *S. mansoni* using the Point of care CCA method

A total of 386 children were examined for *S. mansoni* infection by the use of *S. mansoni* urine Point of care CCA (POC-CCA) method .Two positivity criteria were taken into consideration, one where weak positives (traces) (CCAt-) were considered to be negative and the other where weak positives (traces) were considered to be positive (CCAt+) (see section 3.10). When weak positives were considered to be negative prevalence of *S. mansoni* is 45.9%, (95% CI: 40.9-50.9) and when weak positives were considered to be positives the prevalence is 80.1%, (95% CI: 76.0-84.0). Table 4.2 shows the prevalence of *S. mansoni* by different diagnostic methods.

4.3.3 Prevalence of *S. mansoni* with combined results positive criteria (Kato-Katz and CCA (t+)

A total of 375 children had provided both urine and stool and were examined for *S. mansoni* by using both. The prevalence of schistosomiasis due to combined positivity criteria of both Kato Katz and CCA (t+) was 82.1% (95% CI: 78.2-86.0).Table 4.2.

Table 4.2: The prevalence of *S. mansoni* by different diagnostic methods

Diagnostic method	No examined	No. Positive	Prevalence	95% CI
KK	383	170	44.39	39.38-49.38
CCAt-	386	177	45.85	40.86-50.85
CCA t+	386	309	80.05	76.04-84.05
K-K and CCAt+	375	308	82.13	78.23-86.02

4.3.4 The prevalence of *S. mansoni* infection by sex and age

Of the 383 stool specimens examined for *S. mansoni* eggs, 170 were found to be positive but overall prevalence by Katz-Katz was 44.4%, (95% CI: 39.4-49.4) the prevalence in males was 46.2% (90/195), (95% CI: 39.0-53.2), and 42.6% (80/188), (95% CI: 39.4-49.7) in females There was no difference in prevalence between the males and the females ($\chi 2$ =0.50, P= 0.48).

The prevalence of infection increased with age (χ^2 =61.8, *P*=0.00), with the youngest age group, 1-<2 years, exhibiting a moderate prevalence of 16.9% and the much older age group, 6-<7 years, a high prevalence of 72.7%. The prevalence of infection reached high (>50%) in the age group 4-<5 years. The prevalence of *S. mansoni* infection based on the Kato-Katz stool smear results stratified by age and sex is shown in table 4.3 and figure 4.2.

Table 4.3: Prevalence of *S. mansoni* (Kato-Katz) by sex and age

Variable	*S. mansoni* status		χ2	P-value
	Negative n (%)	Positive n (%)		
Sex				
Male	105 (53.85)	90 (46.15)	0.50	0.48
Female	108 (57.45)	80 (42.55)		
Age				
1-<2	49 (83.05)	10 (16.95)	61.87	0.00
2-<3	57 (77.03)	17 (22.67)		
3-<4	38 (56.72)	29 (43.28)		
4-<5	27 (48.21)	29 (51.79)		
5-<6	26 (36.62)	45 (63.38)		
6-<7	15 (27.27)	40 (72.73)		
Total	213 (55.61)	170 (44.39)		

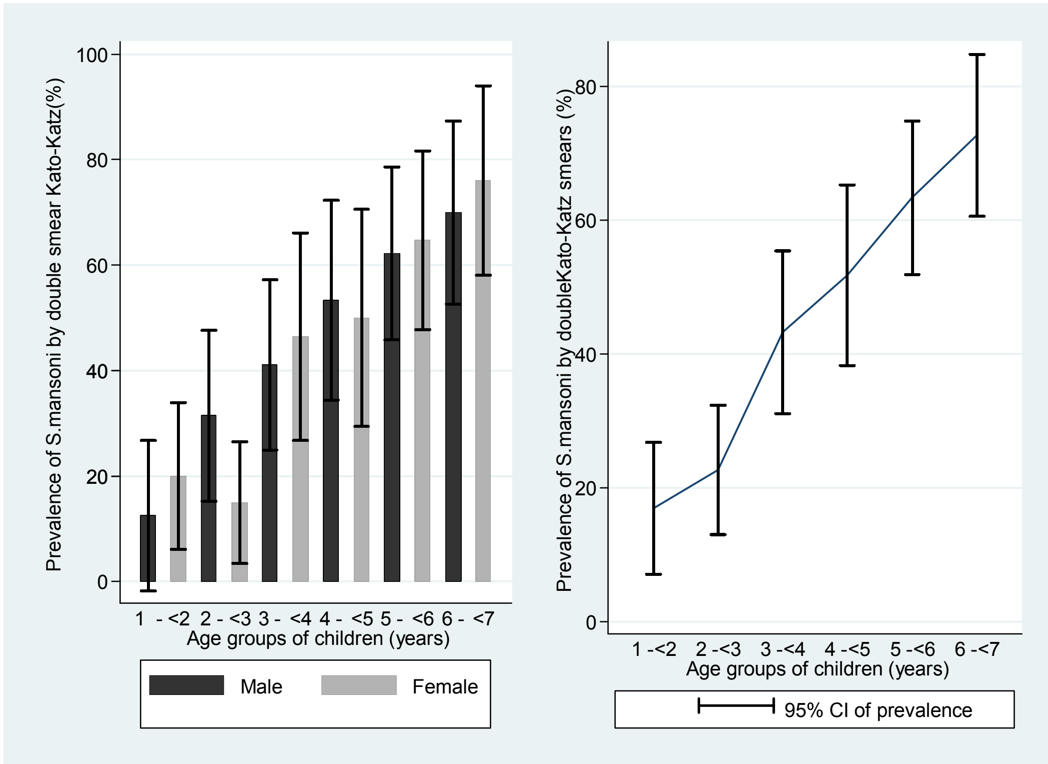

Figure 4.2: Prevalence of *S. mansoni* based on Kato-Katz technique among 383 preschool children of Musozi villages, north-western Tanzania, stratified by sex and age.

The prevalence of *S. mansoni* infection based on Point of Care-Circulating Cathodic Antigen Urine (POC-CCA) cassette tests, stratified by age and sex, is shown in table 4.4, 4.5 and figure 4.3. Considering prevalence of *S. mansoni* by use of CCA-trace negative (t-) the prevalence was 45.9% (95% CI: 40.9-50.9). The prevalence of *S. mansoni* in male children was 48.2% (95% CI: 41.2-51.2) while the prevalence in female children was 43.3% (95% CI: 36.2-50.5). There was no difference in prevalence with sex ($\chi2$ 0.94 P=0.33). Stratified by age, the prevalence of *S. mansoni* was 21.0%, 18.4%, 38.8%, 57.9%, 69.6% and 78.2% for age groups 1-<2, 2-<3, 3-<4, 4-<5, 5-<6, 6-<7 years respectively. There was significant difference in prevalence of *S. mansoni* with age ($\chi2$ 81.94, P=0.00)

Considering prevalence of *S. mansoni* by use of CCA-trace positive(t+) the prevalence of *S. mansoni* was 80.1%, (95% CI: 76.0-84.0). The prevalence of *S. mansoni* in male children was 80.9% (95% CI: 75.3-85.3), while the prevalence for females was 79.1% (95% CI: 73.3-85.0). There was no difference in prevalence of *S. mansoni* between males and females $\chi2$ 0.19 P =0.66 respectively. Stratified by age, the prevalence of *S. mansoni* (CCAt+) was 69.3%, 64.5%, 76.1%, 93.0%, 87.0% and 96.0% for age groups 1-<2, 2-<3, 3-<4, 4-<5, 5-<6, 6-<7 years respectively. There was significant difference in prevalence of *S. mansoni* with age ($\chi2$ 33.83 P=0.00).

Table 4.4: Prevalence of *S. mansoni* (CCAt-) by sex and age

Variable	*S. mansoni* status		$\chi2$	P-value
	Negative	Positive		
Sex				
Male	103 (51.76)	96 (48.24)	0.94	0.33
Female	106 (56.88)	81 (43.32)		
Age				
1-<2	49 (79.03)	13 (20.97)	81.94	0.00
2-<3	62 (89.58)	14 (18.42)		
3-<4	41 (61.19)	26 (38.81)		
4-<5	24 (42.11)	33 (57.89)		
5-<6	21 (30.43)	48 (69.57)		
6-<7	12 (21.82)	43 (78.18)		
Total	209 (54.15)	177 (45.85)		

Table 4.5: Prevalence of *S. mansoni* (CCAt+) by sex and age

Varible	*S. mansoni* status		χ2	P-value
	Negative	Positive		
Sex				
Male	38 (19.10)	161 (80.90)	0.19	0.66
Female	39 (20.86)	148 (79.14)		
Age				
1-<2	19 (30.65)	43 (69.35)	33.83	0.00
2-<3	27 (35.53)	49 (64.47)		
3-<4	16 (23.88)	51 (76.22)		
4-<5	4 (7.02)	53 (92.98)		
5-<6	9 (13.04)	60 (86.96)		
6-<7	2 (3.64)	53 (96.36)		
Total	77 (19.95)	309 (80.05)		

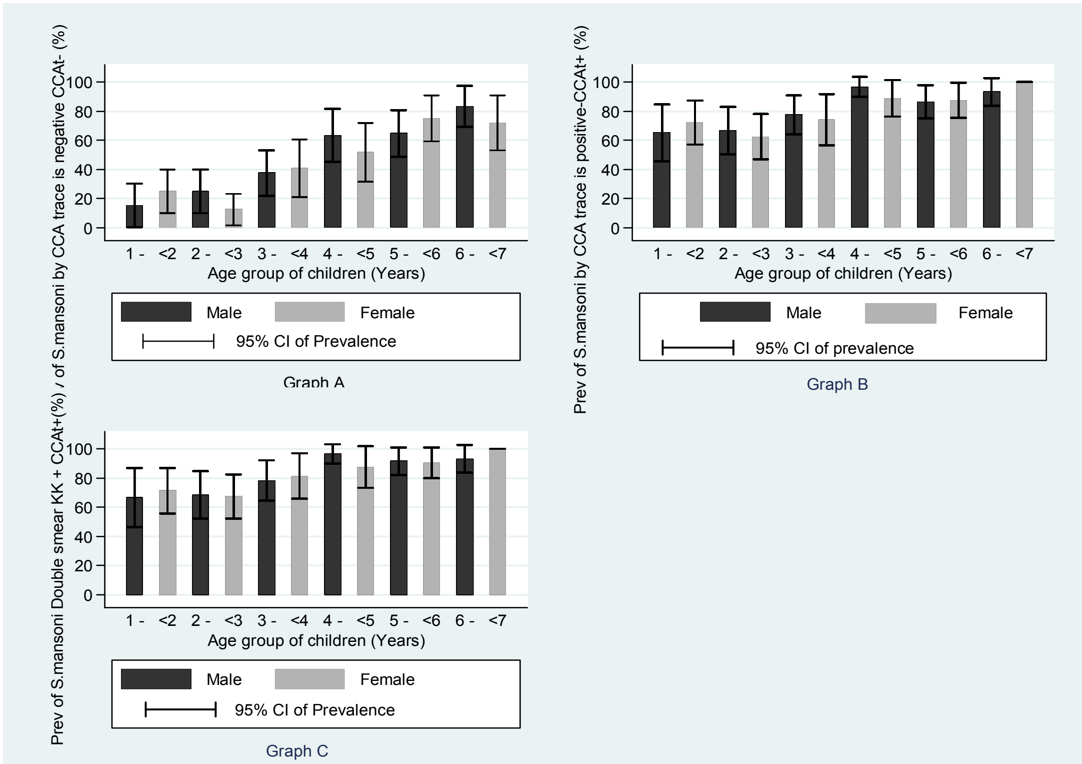

Figure 4.3: Prevalence of *S. mansoni* based on circulating cathodic antigen

A: not including trace (386 pre-school children) and B:including trace (386 preschool children) and C: combined Kato-Katz and CCA trace positive among 375 pre-school children of Musozi villages, north-western Tanzania, stratified by age.

4.4 The intensity profile of *S. mansoni* in preschool children in Musozi village Ukerewe Island

The intensity profile of *S. mansoni* in preschool children in Musozi village is shown in table 4.6 The overall geometric mean intensity for preschool children studied in Musozi village was 110.61, (95%CI: 93.14-131.35eggs per gram which falls in the moderate intensity category (100-399). There was no significant difference in geometric mean intensity between males (118.88epg) and females (102epg) t= 0.83, P=0.80).There is significant increase in GMI with increase in age (F= 6.38, P=0.00).

The proportions of preschool children with heavy, moderate and light infections among those who were Kato-Katz positive are 14.71%, 38.24%, and 47.06% respectively figure 4.4.

Table 4.6: The intensity profile of *S. mansoni* in preschool children in Musozi village

Age cat	Male GMI (epg)	95% CI	Female GMI (epg)	95% CI	Combined GMI (epg)	95%CI
1-<2	283.9	25.5-2122.8	45.8	15.8–134.8	74.7	29.7–189.6
2-<3	94.87	39.3–229.0	46.0	10.8–195.5	73.5	39.9–146.4
3-<4	96.88	58.5–160.4	62.4	33.6–115.5	79.5	54.6–115.8
4-<5	85.23	46.2 –157.2	100.8	51.5–197.2	90.9	60.1–140.4
5-<6	148.68	94.5 –234.0	209.5	133.9–327.6	175.8	128.9–239.7
6-<7	143.29	80.5–255.0	108.0	71.7–162.7	125.3	88.6–117.2

GMI= Geometric mean intensity   Agecat=age categories

Epg= Eggs per gram   CI= Confidence Interval

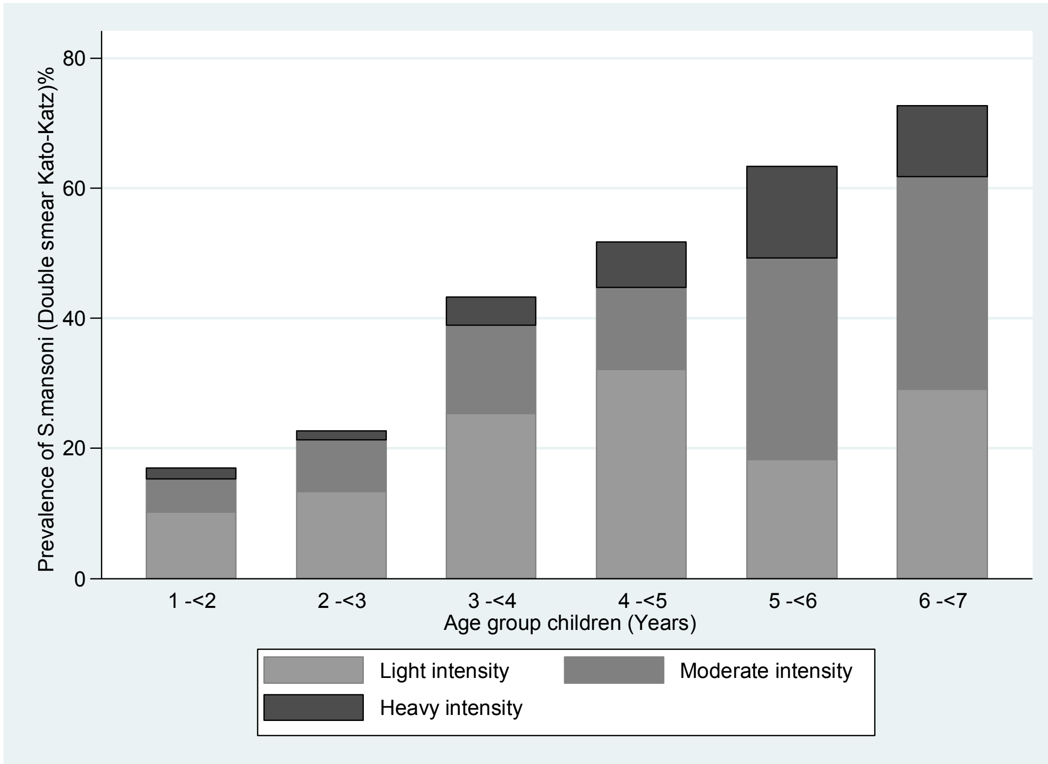

Figure 4.4: Graph of Prevalence and Intensity categories by age category.

4.5 Factors associated with *S. mansoni* infection in preschool children

The association between the prevalence of *S. mansoni* infection and demographic characteristics, water contact patterns and distance from the lake water contact point are shown in table 4.7. Age (P=0.01), history of going to the lake (*P*=0.01), mode of contact (*P*=0.01), frequency of lake visits (P=0.01) were significantly associated with *S. mansoni* infection.

Table 4.7: Prevalence of infection with S. mansoni in preschool children in Musozi village in relation to demographic characteristics water contact patterns and distance from the lake water contact point.

Characteristic	No Examined	No Infected (Prevalence)	95% confidence interval	χ2 P value
Sex				
Female	183	149 (81.42)	75.73-87.11	
Male	192	159 (82.81)	77.43-88.20	0.73
Age (years)				
1-<2	59	41(69.45)	57.39-81.59	
2-<3	75	51(68.00)	57.19-78.80	
3-<4	64	51(79.69)	69.56- 89.82	
4-<5	54	50(92.59)	89.38-99.80	
5-<6	68	62(91.18)	84.26-98.09	
6-<7	55	53(96.36)	91.25-101.47	0.00
Go to the lake				
No	94	58(61.70)	7.10- 14.41	
Yes	279	249(89.25)	85.58-92.90	0.00
Mode of contact				
Never	97	59(60.82)	50.94-70.71	
Accompanied	255	227(89.02)	85.16-92.88	
Alone	21	21(100)	.	0.00
Frequency				0.00
Never	206	148(71.84)	65.65-78.04	
Moderate	59	51(86.44)	77.44-95.44	
High	105	105(100)	.	
Who				
Father	7	6(85.71)	50.76-120.67	
Mother	89	85(95.51)	91.11-99.89	0.68
Self	10	10(100)	.	
Guardian	6	6(100)	.	
Sibling	49	46(95.03)	86.92-100.83	
Distance				
≤500m	146	117(80.14)	73.58-86.68	
>500m	154	131(85.06)	79.37-90.75	0.26

Independent factors associated with the prevalence of infection are shown in table 4.8. In a multivariate model, history of going to the lake (AOR=2.13, 95% CI: 1.06-5.01, P=0.03) and living at a distance of less than 500meters from the lake water contact point (AOR= 2.09, 95% CI: 1.05-4.14, P=0.03) were associated with the infection with *S. mansoni*.

Table 4.8: The factors associated with the Prevalence of infection in preschool children in Musozi village Ukerewe district.

Characteristic	Bivariate			Multivariate		
	Odds Ratio	95% Confidence Interval	P-value	Adjusted Odds Ratio	95% Confidence Interval	P-value
Sex						
Female	1			1		
Male	1.09	0.65-1.87	0.73	1.02	0.51-2.03	0.95
Age (years)						
1-<2	1			1		
2-<3	0.93	.45-1.94	0.85	0.64	0.26-1.61	0.35
3-<4	1.72	.76-3.92	0.20	1.11	0.40-3.10	0.83
4-<5	5.49	1.72-17.49	0.00	2.56	0.61-10.71	0.20
5-<6	4.54	1.66-12.78	0.00	1.32	0.37-4.62	0.66
6-<7	11.63	2.55-53.01	0.00	2.28	0.41-12.46	0.34
Go to the lake						
No	1			1		
Yes	5.15	2.94-9.04	0.00	2.31	1.06-5.01	0.03
Mode of contact						
Never	1			.	.	.
Accompanied	5.22	2.96-9.20	0.00	.	.	.
Alone	.	.	.	.	.	.
Frequency						
Never	1			1		
Moderate	2.50	1.11-5.58	0.03	1.54	0.54-4.37	0.409
High	.	.	.	.	.	.
Who						
Father	1			.	.	.
Mother	3.54	0.34-36.8	0.29	.	.	.
Self	.	.	.	.	.	.
Guardian	.	.	.	.	.	.
Sibling	2.56	0.22-28.67	0.45	.	.	.
Distance						
>500m	1			1		
≤500m	1.59	0.84-2.98	0.14	2.09	1.05-4.14	0.034

The association between the intensity of *S. mansoni* infection, demographic characteristics, water contact patterns and distance from the lake water contact is shown in table 4.9**.** Age (*P*=0.00), history of going to the lake (*P*=0.00), mode of contact (*P*=0.00) and frequency of lake visits (P=0.00) were significantly associated with *S. mansoni* infection.

Table 4.9: The relationship between the geometric mean of intensity of infection (GMI) in preschool children in Musozi village in Ukerewe North Western and the demographic characteristics

Characteristic	No infected	GMI	95% CI	P-values
Sex				
Male	80	101.9	79.2-131.4	0.41**
Female	90	118.9	93.7-150.8	
Age				0.00***
1-<2	10	74.7	29.4-189.6	
2-<3	17	73.5	36.9-146.4	
3-<4	29`	79.5	54.6-115.8	
4-<5	29	91.9	60.1-140.4	
5-<6	45	175.8	128.9-235.7	
6-<7	40	125.3	88.6-177.2	
Go to the lake				0.00**
No	21	77.6	45.2-133.3	
Yes	149	116.3	97-139.4	
Mode of contact				0.00***
Never	21	77.6	45.2-133.3	
Accompanied	136	109.7	90.6-132.8	
Alone	13	213.6	124.4-366.6	
Frequency				0.00***
Never	57	75.7	55.2-104	
Moderate(1-3)	33	93.5	66.9-130.5	
High(4-7)	76	117.9	117.9-193.8	
Who				
Father	5	101	46.3-220.5	
Mother	34	133.7	92-194.3	
Self	62	122.7	93.3-161.5	
Guardian	6	350.7	137.9-892	
Sibling	3	122	7.6-1967	
Distance				0.28**
>500m	70	123.1	92.8-163.1	
≤500m	71	108.9	83-142.9	

**Determined by t-test ***Determined by ANOVA

The independent factors associated with log-transformed egg counts of *S. mansoni* are shown in table 4.10. In a multivariate model, high frequency (4-7 days per week) of going to the lake (OR=1.84,1.18-2.86, P=0.00) remained associated with a heavy intensity of infection.

Table4.10: The factors associated with log transformed egg counts in preschool children in Musozi village Ukerewe district North Western Tanzania.

Characteristic	Bivariate			Multivariate		
	OR	95% CI	P-value	AOR	95% CI	P-value
Sex						
Female	1			1		
Male	1.16	0.83-1.64	0.38	1.17	0.83-1.65	0.13
Age (years)						
1-<2	1					
2-<3	0.98	0.41-2.34	0.97	.94	0.39-2.24	0.88
3-<4	1.06	0.47-2.36	0.87	0.98	0.43-2.26	0.97
4-<5	1.23	0.55-2.73	0.60	1.10	0.47-2.56	0.81
5-<6	2.35	1.10-5.03	0.02	2.05	0.90-4.69	0.08
6-<7	1.67	0.78-3.62	0.19	1.49	0.65-3.41	0.33
Go to the lake						
No	1			1		
Yes	1.49	0.89-2.51	0.12	0.74	0.39-1.41	0.36
Mode of contact						
Never	1					
Accompanied	1.41	0.84-2.37	0.19			
Alone	2.75	1.26-6.00	0.01			
Frequency						
Never	1			1		
Moderate	1.23	0.76-1.98	0.38	1.30	0.77-2.19	0.30
High	1.99	1.36-2.91	0.00	1.84	1.18-2.86	0.00
Who						
Father	1					
Mother	1.20	0.26-5.57	0.80			
Self	1.21	0.46-3.21	0.69			
Guardian	1.32	0.48-3.60	0.58			
Sibling	3.47	0.97-12.34	0.05			
Distance						
>500m	1					
≤500m	0.88	0.60-1.30	0.53			

CHAPTER FIVE

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Discussion

5.1.1 Prevalence of *S. mansoni* infection

In the present study area, it appears that *S. mansoni* infection starts at an early age and is associated with various risk factors. This adds to the growing body of evidence that preschool children can have schistosomiasis. The prevalence was observed to vary by age groups but not by sex. Infections with *S. mansoni* were predominantly light, but moderate intensity and heavy intensity infections were increasingly becoming common from the age of three years. The main identified risk factors associated with *S. mansoni* infection in preschool children were history of water contact and living at a distance of less than 500 meters from the lake water contact point. A bathing frequency at the lake of 4-7 days per week was associated with a heavier intensity of infection.

The prevalence of egg patent *S. mansoni* infection was 44.39% based on Kato-Katz, 45.85% based on CCA when trace was considered as negative and 80.05% on CCA when trace was considered as positive, of all the PSC who participated in the study. The prevalence estimates as determined by single stool double smear Kato-Katz and CCA with trace considered as negative (CCAt-) are broadly similar, however, the 35% increment in prevalence observed when trace is considered as positive (CCAt+) is noted. It has been previously noted that when assessing the prevalence of *S. mansoni* using the CCA test alongside K-K, there is a higher 'true' prevalence with CCA than observed prevalence by K-K rather than the CCA test yielding a high number of false positives (Navaratnam *et al*., 2012). The 'traces' for this study could partly be accounted for by the fact that in this population most of the children have light infection as noted by the

Kato-Katz, therefore, it is possible that the traces can be explained by pre-patent infections.

The overall prevalence of *S. mansoni* observed in this study was higher than that reported on the same age-group in Uganda on the shores of Lake Albert and Lake Victoria (Sousa-Figueiredo, Betson, Kabatereine, & Stothard, 2013), in Usoma, Kenya (Verani *et al*., 2011) and in Ivory Coast (Coulibaly, N'Gbesso, N'Guessan, *et al.*, 2013) in West Africa.

5.1.2 Intensity of *S. mansoni* infection

The overall geometrical mean in the present study was of moderate intensity and the majority of the children had light to moderate infection intensities. Only 6.53% of the study participants most of them aged three years and above presented with heavy intensities. The intensity of *S. mansoni* infection was observed to increase with an increase in the age of the study participants. The results of the present study also show that there was no significant difference in intensity of infection by sex. This is likely due to a similarity of PSC's water contact behaviour and parents' or guardians' behaviour towards their children's water contact between the two sexes. As they grow older this similarity is lost as their behaviour towards water contact changes. This is affirmed by higher prevalence and intensity of *S. mansoni* in males than females in school children. Similar findings were reported in Ivory Coast (Coulibaly, N'Gbesso, N'Guessan, et al., 2013). In comparison to studies conducted on the shores of the Lake Victoria in Uganda (Sousa-Figueiredo *et al.,* 2013) and West Africa (Coulibaly, N'Gbesso, N'Guessan, *et al*., 2013), the prevalence of heavy infection among PSC was higher in the present study. This could be due to the behavior of this population group especially those living ≤500m from the lake and their repeated contact with contaminated water and lack of safe water for bathing and improved sanitation facilities. Adult individuals living in this particular setting have been repeatedly reported to be highly infected with *S. mansoni* and carry the highest intensities of infection (Kardorff *et al.*, 1997; Malenganisho *et al.,* 2008).

Increased water contact activities such as fishing, bathing and farming were associated with an increased risk of being infected with *S. mansoni* in the adult population (Kloos, Gazzinelli, & Van Zuyle, 1998).

One remarkable observation was that heavy infections were more common from the age of three years onwards where the prevalence was 4.4% in 3-year-olds and 10.9% in 6-year-olds. This has shown that young children can have heavy infections even at an age as young as three years old. It has been depicted that the heavier the infection the more severe the morbidity; however, even light egg patent infections (Berhe, Myrvang, & Gundersen, 2007; Boisier, Ramarokoto, Ravoniarimbinina, Rabarijaona, & Ravaoalimalala, 2001) and sub-egg patent infections are considered to be detrimental to well-being, especially in younger children (Gurarie, Wang, Bustinduy, & King, 2011; Terer *et al.,* 2013). It is therefore important to focus on these children because they are set to suffer significant morbid effects as explained by King and Dangerfield-Cha (King & Dangerfield-Cha, 2008) and mostly because it can take up to three years before they are treated.

5.1.3 Risk factors associated with prevalence and intensity of infection

This study also examined the risk factors associated with *S. mansoni* infection in PSC, whereby the results show a significant association between the history of a visit to the lake and the infection with *S. mansoni* in this age group. Those who reported going to the lake had twice the odds of being infected with *S. mansoni* infection. This is supported by an observation made in western Kenya where reported water contact with the lake was associated with the infection with *S. mansoni* (Handzel *et al.,* 2003). The distance from the water contact point was strongly associated with the infection with schistosomiasis, whereby, those who lived <500m from the lake water contact point were at twice the odds of being infected with *S. mansoni* infection. It has been demonstrated that for this age group, the distance from the water point and the history of visiting the lake were significant factors for schistosomiasis infection. This is particularly important as lake water, which is the source of water for bathing and other domestic uses including drinking for some of the villagers, was continuously contaminated with *S. mansoni* eggs from the poor sanitation practice of defaecating in the lake water. This corroborates studies carried out in Western Kenya (Handzel *et al.*, 2003) and Tanzania (Lwambo, Siza, Brooker, Bundy, & Guyatt, 1999) which found that the prevalence of infection decreases with the increase of the distance from the lake water shore. A history of a high frequency of bathing in lake water, (4-7 days) per week, was shown to be associated with a heavy *S. mansoni* infection where those who had high bathing frequency in lake water were at a 1.8 higher odds of heavy infection.

5.2 Conclusions

i. The prevalence of *S. mansoni* in preschool children in Musozi village in Ukerewe based on Kato-Katz and the circulating cathodic antigen (with traces considered negative) was moderate and high on the the circulating cathodic antigen (with traces considered positive) .
ii. Moderate and heavy intensity of infections are common among the children aged 3 years and above.
iii. Going to the lake for bathing and living at a distance of ≤500 meters from the lake were associated with a significant risk of being infected with *S. mansoni*.

5.3 Limitations

This present study is subject to some limitations. The findings of this study only apply to the geographical setting where the study was undertaken and may not be generalised to other geographical settings.

5.4 Recommendations

i. It is, therefore, important to consider including children of 3 years in PZQ-MDA programmes because they are set to suffer the significant morbid effects of chronic schistosomiasis.

ii. It is important to provide health education for behaviour change to avoid contaminated lake water for the whole village community.

iii. Provision of safe water for the whole community and especially for those who live close to the lake for all domestic uses including bathing is necessary so that the children would stop bathing in the lake which is contaminated with schistosome cercaria.

iv. More studies to quantify the prevalence of *S. mansoni* infection in that particular age group should be carried out at the country level.

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APPENDICES

Appendix i: Questionnaire

Study participant questionnaire form

PART A.GENERAL INFORMATION

1. Village name____

2. Ward ____

3. District____

4. Subject ID number____

5. Demographic data

6. Date of birth______________(dd-mm-yyyy), Estimated age in months______

7. Sex ☐ Male ☐ Female

8. Marital status of caretaker

☐ Single ☐ Married ☐ Divorced ☐ Widowed ☐ Cohabiting

9. Education level of caretaker

☐ Never been to scho☐ Primary edu☐ion Secondary☐ducation University

10.Occupation of mother/Parent/guardian

☐ Peasant ☐ fisherman ☐ fishtrader ☐ Housewife ☐ Other

____________________________(mention if other)

11. GPS coordinates of homestead______________________

12. GPS coordinates of nearest lake contact point.__________________________

PART B.HYGIENE/SANITATION

13. Is there a toilet/pit latrine ☐ Yes ☐ No

14. Does the child use it?

☐ Yes ☐ No

15.Is there tap water at your village?

☐ Yes

☐ No

PART C. Water contact habits

16. Has the child come into contact with lake water? ☐ Yes ☐ No

17. If YES, how has the child come into contact with water?

Escorts mother/caretaker/older sibling to the lake ☐

Water fetched from the lake to the homestead ☐

Child goes unaccompanied to the lake to swim wash play or fetch water ☐

Child has never been to the lake ☐

18. Where has the child bathed in the previous week

Day	Lake	Home
Monday		
Tuesday		
Wednesday		
Thursday		
Friday		
Saturday		
Sunday		

19. In the previous week how many times the child has been to the lake, with who, what was the principal activity there, was the child in contact with the water

Day	Lake (Y/N)	With who (MOTHER,CAREGIVER,SIBLING,ALONE)	Activity	Water contact(Y/N)
Monday				
Tuesday				
Wednesday				
Thursday				
Friday				
Saturday				
Sunday				

PART D. ANALYSES

. Stool Analysis

20. Stool sample given and adequate ☐ Yes ☐No

21. *S. mansoni* ☐ Positive ☐ Negative

22.If positive, mean egg intensity is ______________________

23.Other helminths ☐ Positive ☐ Negative

24.If positive which one__________________________

Urine CCA

25. Urine sample given

Reaction ☐ Positive ☐ Negative

26 If positive strength of reaction ________________________

Appendix ii: Consent seeking document

CONSENT FORM

Section I: Information

TITLE: PREVALENCE INTENSITY AND ASSOCIATED RISK FACTORS OF INTESTINAL SCHISTOSOMIASIS AMONG PRESCHOOL CHILDREN AGED IN UKEREWE ISLAND, NORTH-WESTERN TANZANIA.

INVESTIGATORS: Deodatus M Ruganuza ITROMID/JKUAT P.O.Box 62000-00200 Nairobi Kenya and Catholic University of Health and Allied Sciences P.O Box 1464 Mwanza,Tanzania; Dr Gerald Mkoji CBRD–KEMRI P.O.Box 54840-00200 Nairobi, Kenya; Prof. Rebecca Waihenya JKUAT P.O.Box 62000-00200, Nairobi, Kenya

INTRODUCTION:

Dr Deodatus M Ruganuza of the Institute of Tropical Medicine of the Jomo Kenyatta University of Agriculture university & Catholic University of health and allied sciences, Dr Gerald Mkoji of the Kenya Medical research Institute (KEMRI) and Prof Rebecca Waihenya of the Jomo Kenyatta University of Agriculture and Technology (JKUAT) are conducting research on Intestinal schistosomiasis in preschool children. Worms that are transmitted by fresh water snails. The purpose of this study is to enable us to understand the extent to which the disease affects preschool children so that ways implementation of control in this particular age group can be justified. Currently the main control strategy against schistosomiasis is by use of chemotherapy primarily targeting school going children leaving preschool children neglected. We choose to carry out this study because its an area highly endemic for Intestinal schistosomiasis and the prevalence of infection in school going children adolescents and adults in the same geographical area is known. To carry out this study we enroled children younger than 7 years (which is the national age for starting primary school in Tanzania).However we needed permission from their parents/guardians to include their children into the study. From each child, with permission from the parent guardian we asked for sufficient amount of stool sample and a urine sample so that we can screen for intestinal schistosomiasis. All the children found to be positive for intestinal schistosomiasis and soil transmitted helminthiases were treated free of charge. Children found or suspected to have any other medical conditions were referred to the nearest health center but the parents/Guradians will have to meet the medical expenses for these other conditions. As a parent/Guardian we request your permission for your child to take part in this study. Taking part in this study is voluntary and you and your child can still leave this study if you decide to do so at any time in the future without suffering any penalty or loss or loosing benefits available for him or her through this study. Please read this information sheet carefully and when you have read feel free to ask questions or to seek clarification now or at any time in the future on any issue concerning your child's participation in the future.

.

PURPOSE OF THE STUDY

The purpose of this research is

1. To determine the prevalence of intestinal schistosomiasis in preschool children living in Ukerewe Island, Mwanza Region, Tanzania
2. To determine the intensity profile of intestinal schistosomiasis in preschool children in Ukerewe Island.
3. To determine factors associated with intestinal schistosomiasis among preschool children on the Island.

PROCEDURES

If you allow your children to volunteer to participate in this study we will ask your child to provide an early morning stool sample in a container for examination of *S. mansoni* and urine sample also for determination of *S. mansoni*. Stool samples obtained were processed using Kato-Katz technique for examination for *S. mansoni* ova. Urine will also be tested for *S. mansoni* using CCA cassettes. A structured questionnaire will be administered to capture factors associated with infection.

BENEFITS

Your child will get lab diagnosis of *S. mansoni* and Soil transmitted helminthiases in case the child will be found to be infected he/she received treatment according to the national treatment guidelines.

POTENTIAL RISKS AND DISCONFORTS

We do not anticipate any serious risk for your child to participate in the study. The procedure of obtaining the sample involve normal life processes ie defaecation and urination. The information gathered in the questionnaire will pose minimal risk as they will ask on demographic data and water contact patterns. Morever all the information gathered on the questionnaire is confidential and cannot be easily traced back to the study participant.

CONFIDENTIALITY

Research results were published and discussed in conferences results in questionnaires can only be traced back to the study participants using the participant identification number .If photographs videos or audio tapes of your children were used identity of the child/children was protected. Data was kept in a computer protected with a password.

PARTICIPATION AND WITHDRAWAL

The participation of your child/children is voluntary. If you choose not to allow your child to participate it will not affect your relationship with the village authority. You can still get treatment at the nearest health center. If you decide for your child to participate you are free to withdraw your consent and discontinue your child/children from participation at any time without prejudice.

IDENTIFICATION OF INVESTIGATORS

For further information on this study or in the event of a research related injury or if your child/children experience an adverse reaction, please immediately contact Dr Deodatus M Ruganuza, Catholic University of Health and Allied Sciences P.O.Box 1464 Mwanza, Tanzania. Mobile +255767186110 and deorugz@gmail.com.

RIGHTS OF RESEARCH SUBJECTS

You may withdraw your consent for your child/ children at any time and discontinue them from participation without penalty. You are not waiving any legal claims rights or remedies because of allowing your child /children to participate in this research study. If you have any questions about your rights or rights of your children as research subjects you may contact If you have questions about the rights of your child as a research participant, please contact: The Secretary, KEMRI Ethics Review Committee, PO Box 54840-00200, Nairobi; Phone: 020-2722541, 0722-205901, 0733-400003; e-mail: ERCAdmin@kemri.org

SECTION II: CONSENT

INFORMED CONSENT AGREEMENT FOR PARENTS/GUARDIANS

I have read the information provided above. I have been given an opportunity to ask question and all of my questions have been answered to my satisfaction. I have been given a copy of this form.

I______________________________________(Name of a parent or guardian) being 18 years or older and a guardian/ parent of ________________________. I give permission to Dr/Prof/Mr/Mrs/Miss ______________________ for my child to participate in this study.

The new study named 'PREVALENCE AND INTENSITY OF INTESTINAL SCHISTOSOMIASIS AND THE ASSOCIATED FACTORS IN PRESCHOOL CHILDREN IN UKEREWE ISLAND, MWANZA REGION IN NORTH-WESTERN TANZANIA' which was explained to me in ______________ language which I speak fluently. I know what the study is all about the tests about to be done to my child the benefits my child will receive by participating in this study the side effects he/she could suffer from the medication he/she will receive if found with intestinal schistosomiasis and/or intestinal helminthiases which I have been told, are mild, temporary, and should not cause any harm to my child. I was given an opportunity to ask questions and to seek clarifications of the issues I had not understood clearly about the study, and I am satisfied with the answers and the explanations I was given. I have also, been told that if I have additional questions or concerns about the study later, I can contact the researcher in charge of the study, and if I have questions or concerns about my child's rights as a participant in this study, I can contact: The Secretary, KEMRI's Ethics Review Committee, Kenya Medical Research Institute (KEMRI), P.O. Box 54840-00200, Nairobi, Phone: 020-2722541, 0722-205901, 0733-400003; e-mail: ERCAdmin@kemri.org

I accept my child to take part in this study and agree he/she can give stool and urine samples for the tests needed in this study. I have been told that my child may leave this study at anytime and I have been assured that he/she will not suffer any penalty or loss of benefits that he should get through this study. All the things have been explained to me in ___________________the language which I speak fluently.

Signature/Thumb print___________________ Date __________________________

Name of Person obtaining consent and
Signature______________________________________

Witness I certify that the participant have agreed to participate in the study without being forced.

Signature_________________________________Date_______________________

Appendix iii: Thesis Publication

Ruganuza et al. Parasites & Vectors (2015) 8:377
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Parasites & Vectors

RESEARCH Open Access

Schistosoma mansoni among pre-school children in Musozi village, Ukerewe Island, North-Western-Tanzania: prevalence and associated risk factors

Deodatus M. Ruganuza[1,3*], Humphrey D. Mazigo[1], Rebecca Waihenya[2], Domenica Morona[1] and Gerald M. Mkoji[4]

Abstract

Background: Recent evidence indicates that pre-school children (PSC) living in *S. mansoni* highly endemic areas are at similar risk of schistosomiasis infection and morbidity as their school aged siblings. Recognizing this fact, the World Health Organization (WHO) is considering including this age group in highly endemic areas in control programmes using mass drug administration (MDA). However, detailed epidemiological information on *S. mansoni* infection among PSC is lacking for many endemic areas, specifically in Tanzania. This study was conducted to determine the prevalence of *S. mansoni* infection and its associated risk factors among PSC in Ukerewe Island, North-Western Tanzania.

Methods: This was a cross-sectional study, which studied 400 PSC aged 1–6 years. The Kato-Katz (K-K) technique and the point of care circulating cathodic antigen (CCA) immunodiagnostic test were used to diagnose *S. mansoni* infection in stool and urine samples respectively. A pre-tested questionnaire was used to collect demographic data and water contact behaviour of the children from their parents/guardians.

Results: Based on the K-K technique, 44.4 % (95 % CI: 39.4–49.4) pre-school children were infected with *S. mansoni* and the overall geometric mean eggs per gram of faeces (GM-epg) was 110.6 epg with 38.2 and 14.7 % having moderate and heavy intensity infections respectively. Based on the CCA, 80.1 %, (95 % CI: 76.0–84.0) were infected if a trace was considered positive, and 45.9 %, (95 % CI: 40.9–50.9), were infected if a trace was considered negative. Reported history of lake visits (AOR = 2.31, 95 % CI: 1.06–5.01, $P < 0.03$) and the proximity to the lake shore (<500 m) (AOR = 2.09, 95 % CI: 1.05–4.14, $P < 0.03$) were significantly associated with *S. mansoni* infection. Reported lake visit frequency (4–7 days/week) was associated with heavy intensities of *S. mansoni* infection ($P < 0.00$).

Conclusion: The prevalence of *S. mansoni* infection in the study population using K-K and CCA-trace-negative was moderate. The frequency of lake visits and the proximity to the lake shore were associated with the infection of *S. mansoni* and its intensity. These findings call for the need to include the PSC in MDA programmes, public health education and provision of safe water for bathing.

Keywords: *S. mansoni* prevalence, Intensity of infection, Pre-school children, Tanzania

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Background

Schistosomiasis remains a serious public health concern in sub-Saharan Africa and approximately one-third of the 192 million cases of schistosomiasis in the region are caused by *Schistosoma mansoni*, the causal agent of intestinal schistosomiasis [1]. An estimated 4.4 million people infected with *S. mansoni* have bloody diarrhoea and another 8.5 million have hepatomegaly associated with periportal liver fibrosis, portal hypertension and haematemesis [2]. Furthermore, complications of oesophageal varices and haematemesis supposedly result into 130,000 annual deaths [2, 3]. Among the school-going children, a chronic infection with *S. mansoni* contributes towards anaemia, stunted growth, organomegaly and poor cognitive functions; the combination of these morbidities may affect their future life [4, 5].

In Tanzania, studies on *S. mansoni* have been carried out mostly in school children where the prevalence of *S. mansoni* infection ranges from 32 to 64 % and varies from one geographical area to another [6–8], furthermore 46 % lack access to potable water, limiting the use to drinking where available, 87 % lack improved sanitation and 16 % practice open defaecation [9]. In the nearby East African countries the prevalence of *S. mansoni* in preschool children (PSC) was 44.3 and 16 % respectively on the shores of Lake Albert and Lake Victoria in Uganda [10] and 14 % in Lake Victoria in Kenya [11]. Although intestinal schistosomiasis has been known to infect PSC since the early 1950's [12, 13], it is only recently that attention has focused on this particular group [10, 14–20]. For a long time, this age group was considered to be at low risk of severe infection [21]. However, given that the Kato-Katz technique, used for many years in epidemiological surveys of *S. mansoni* infection, has a low sensitivity for infection detection, the prevalence of infection among PSC may have been grossly under-estimated [22–25]. This could have resulted in the exclusion of the age group in the control programmes. It has been suggested that supplementing the Kato-Katz technique with diagnostic techniques that have a greater sensitivity such as the Circulating Cathodic Antigen test (CCA) (Sensitivity between 76.7 and 99.1 %, Specificity of 74.2 %), could improve the detection of infections in PSC [22–31]. As a matter of fact, a higher prevalence was recorded among school children in other endemic areas in sub-Saharan Africa when the CCA immunodiagnostic test was used alongside the Kato-Katz test [10, 11, 32]. However, ambiguity remains for the interpretation of CCA results where the traces in the test band can be considered either negative or positive, affecting the sensitivity of the test [33]. One study has shown a good sensitivity and specificity when traces are considered negative, but specificity is poorer when traces are considered positive [34]. It has been shown that CCA is not affected by *S.haematobium* [35] or Soil-transmitted helminths [36], while on the other hand Lewis-X trisaccharide epitopes can be picked up contributing to false positives [34]. The CCA test was used in the present study in addition to the Kato-Katz test.

Even where schistosomiasis has been investigated among PSC, very little is known about the risk factors associated with the disease in this age group. However, it has been observed that PSC can be exposed to infection when they accompany their parents/guardians or their older siblings to transmission sites [20]. Among the older children, risk factors often associated with schistosomiasis include the distance of households from the water contact points, the involvement in fishing or farming activities, gender and socio-economic status [15, 17, 18, 20, 37].

Although the World Health Organization (WHO) has acknowledged the need to include pre-school aged children in schistosomiasis control programmes, the epidemiological information on schistosomiasis among PSC remains scanty for many endemic areas, including Tanzania, where 51 % of the population is at risk of being infected [38]. The aim of the present study was to determine the prevalence and intensity of *S. mansoni* infection among PSC, aged 1 to 6 years (12–83 months) in an endemic area, the Musozi village on the Ukerewe Island, in North-Western Tanzania and to identify the risk factors associated with the infection.

Methods

Study area and population

Musozi village is located on the main Island of Nansio, in Ukerewe district, Mwanza Region, at approximately 2° S and 33°E in the North-Eastern part of the island, and at an altitude of 1100 m above sea level (Fig. 1). The climate is tropical and temperatures typically range from 17 to 27 °C with a mean annual rainfall of 1090 mm. The area experiences two rainy seasons (a short rainy season between October and January, followed by a short dry spell from mid-January to February), and a long rainy season from March and June. According to the most recent census, the village has 712 PSC aged from 1 to 6 years (12 to 83 months) [39].

Study design, inclusion and exclusion criteria

This was a cross-sectional study of 400 systematically selected PSC aged 1–6 years (12–83 months), who had lived in the study village for at least 6 months before the study began and who had no history of having been treated with Praziquantel (PZQ) in the previous 1 year. A written consent was obtained from parents/guardians of the children, prior to their enrolment into the study.

Data collection

Questionnaire

A structured questionnaire was administered to the PSC's parents or guardians, the questionnaires collected information on the demographic characteristics of the PSC and their parents' demographic characteristics and water contact behaviour as a proxy for their children's risk of water contact. Water contact behaviour was assessed by inquiring on history of water contact i.e. whether the child has ever been to the lake and has had previous contact with

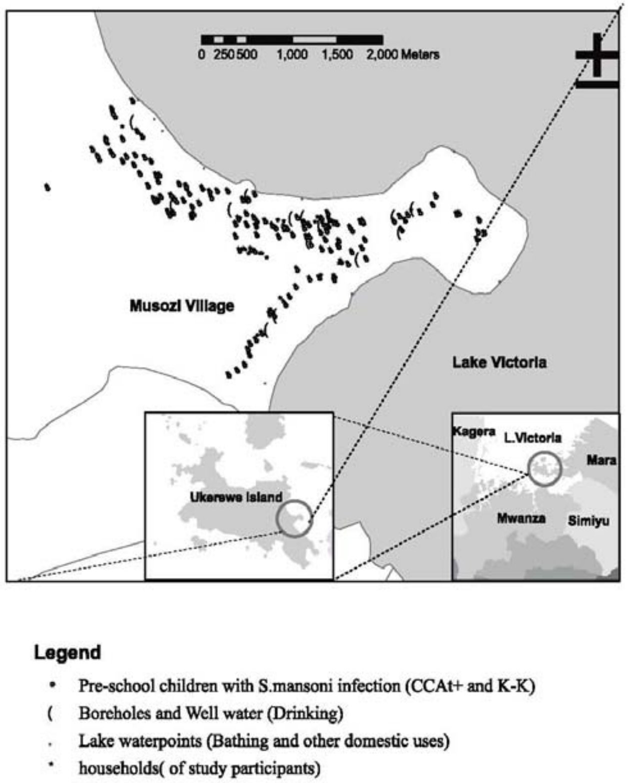

Fig. 1 Map of Musozi village showing households of pre-school children, wells and lake water contact points

lake water, Mode of contact i.e. whether the child goes alone, with sibling or with parents/guardian, frequency i.e. the reported number of days in the last week that the child has been to the lake.

Mapping of the household, lake water points and wells/boreholes

Global positioning system (GPS) data was taken for the study participant household, the closest Lake water contact point (where the household members bathe and fetch water for other domestic uses) and Well water point were taken by using a Garmin etrex handheld GPS receiver (Trimble Navigation, Sunnyvale, CA, USA). Data was recorded on data sheets and was later entered into Microsoft excel 2010 and then ArcGIS ArcMap 10.2.2 were analysis was done to obtain the distance from each household and its nearest lake water contact point. Distance data were taken to Stata for further analysis and the map of the study site was generated.

Parasitological examination of stool samples

Single stool and urine samples were collected in separate clean containers from each of the enrolled children. From each stool sample two Kato-Katz thick smears were prepared using a template that can hold 41.7 mg of stool sample, supplied by Vestergaard Frandsen (Lausanne, Switzerland), according to a standard protocol [23, 40, 41]. The slides were left for 24 h for them to clear for easy visualization of *S. mansoni* eggs. After 24 h, the smears were examined for eggs of *S. mansoni* and other helminths. Two independent and experienced parasitologists examined each slide. For each slide, characteristic eggs of *S. mansoni* that were present were noted by examiners.

Qualitative examination of CCA for S. mansoni in urine samples

In addition to examining Kato-Katz stool smears by microscopy, urine samples were also collected from the enrolled study children and were tested for *S. mansoni* Circulating Cathodic Antigens (CCA) using the CCA Urine Cassette assay (Rapid Medical Diagnostics, Pretoria, South Africa) [42]. The preparation and examination of the urine samples were performed according to the manufacturer's instructions [42]. The results of the test were read 20 min after adding the buffer. If the control bands did not develop, the result was regarded as invalid. Because there is ambiguity in the interpretation of 'trace' in a CCA test band i.e. it can be read as positive or negative [33], we used two categories for diagnostic analysis in which valid results were either scored as trace positive or trace negative.

Ethical considerations

This study was approved by the Kenya Medical Research Institute (KEMRI) Scientific and Ethics Committee (SSC No. 2739) and by the Joint Institutional Review Board of the Catholic University of Health and Allied Sciences (CUHAS) and Bugando Medical Centre, Mwanza, Tanzania (review and publication certificate number: BREC No. 035/2013). Prior to recruiting the study participants, village meetings were held with parents and guardians, under the guidance of village leaders to explain the objectives of the study and the procedure to be used for data collection. Written informed consent was obtained from the parents/guardians of children before their enrolment into the study. Stool and urine collection are routine procedures and do not pose any risks to the study children. Praziquantel and albendazole at the recommended doses were administered to the infected children under the supervision of a qualified clinician. All the information obtained from the children and their parents was treated as private and confidential and the records were stored in a locked cabinet and data were entered in a password protected file in a computer.

Data analysis

The data entered and stored in Microsoft Excel 2007 was checked for entry errors and was analysed using statistical tools available in the STATA version 12 software (STATA Corp, College Station, Texas, USA). The age variable was described as mean ± standard deviation and categorized into age groups: 1- < 2, 2- < 3, 3- < 4, 4- < 5, 5- < 6, 6- < 7 years. Binary variables were compared using the Chi-square test (χ^2) or the Fisher exact test, where appropriate. The intensity of infection was categorized according to WHO criteria as ≤99 epg (light), 100–399 epg (moderate), or ≥400 epg (heavy) [43, 44]. Prevalence of infection was of <10 % is low, ≥10 but <50 % is moderate prevalence and >50 % high prevalence. ANOVA or t-tests were used to test for the difference in mean egg counts for *S. mansoni* between sex and age-groups.

Demographic and socio-economic variables were assessed using logistic regression. The potential associations were first assessed at a bivariate level; then, factors with a *P*-value <0.2 were entered into the multivariate model. Sex and age group term were entered as *a priori* into the multivariate model. Stepwise backward logistic regression was used to determine whether these variables were independent factors of *S. mansoni*. Independent risk factors of faecal egg counts were identified in a linear regression model using a log-transformed egg per gram of faeces (epg) as outcomes variable and social demographic factors as explanatory variables. The odd ratios of each of the risk factors associated with faecal egg counts were obtained by taking the antilogarithm of the regression coefficient.

Results

Demographic characteristics of the study children and prevalence of *S. mansoni* infection

A total of 400 PSC aged 1–6 years (12–83 months) were enrolled into the study. Of these children, 49.2 % (N = 197) were female and 50.7 % (N = 203) were males. The mean age of the children was 3.82 ± 1.6 years. Table 1 shows the age and sex distribution of the children.

Prevalence of *S. mansoni* based on the Kato-Katz technique

Based on the Kato-Katz stool smear results, a total of 170/383 children, 44.4 %, (95 % CI: 39.4–49.4) were found to be infected with *S. mansoni*, with a prevalence in males being 46.2 % (90/195), (95 % CI: 39.0–53.2), and in females 42.6 % (80/188), (95 % CI: 39.4–49.7). No gender-related difference in prevalence was observed (χ^2 = 0.50, $P < 0.48$). The prevalence of infection increased with age ($\chi^2 = 61.8$, $P < 0.00$), with the youngest age group, 1- < 2 years, exhibiting a moderate prevalence of 16.9 % and the much older age group, 6- < 7 years, a high prevalence of 72.7 %. The prevalence of infection

Table 1 Demographic characteristics of 400 pre-school children from Musozi village, in Ukerewe district, north-Western Tanzania

Age (years)	Males	%	Females	%
1- < 2	26	12.81	37	18.78
2- < 3	36	17.73	41	21.81
3- < 4	42	20.69	28	14.21
4- < 5	30	14.78	31	15.74
5- < 6	39	19.21	35	17.77
6- < 7	30	14.78	25	12.69
Total	203		197	

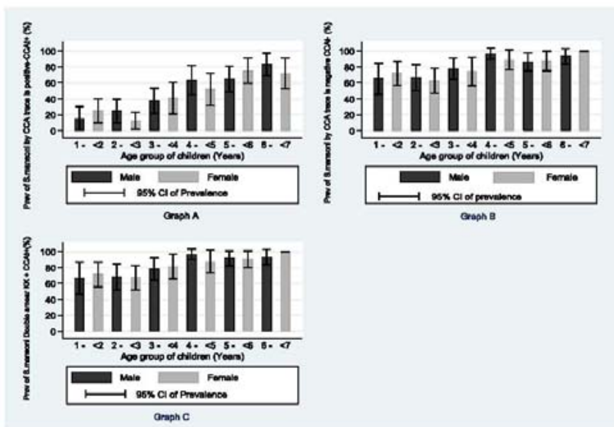

Fig. 3 Prevalence of *S. mansoni* based on circulating cathodic antigen, **a**: not including trace and **b**: including trace and **c**: combined Kato Katz and CCA trace positive among 383 pre-school children of Musozi villages, north-western Tanzania, stratified by age

of lake visits ($P < 0.01$) were significantly associated with *S. mansoni* infection.

Independent factors associated with the prevalence of infection are shown in Table 4. In a multivariate model, history of going to the lake (AOR = 2.13, 95 % CI: 1.06–5.01, $P < 0.03$) and living at a distance of less than 500 m from the lake water contact point (AOR = 2.09, 95 % CI: 1.05–4.14, $P < 0.03$) were associated with the infection with *S. mansoni*.

The association between the intensity of *S. mansoni* infection, demographic characteristics, water contact patterns and distance from the lake water contact is shown in Table 5. Age ($P < 0.00$), history of going to the lake ($P < 0.00$), mode of contact ($P < 0.00$) and frequency of lake visits ($P < 0.00$) were significantly associated with *S. mansoni* infection.

The independent factors associated with log-transformed egg counts of *S. mansoni* are shown in Table 6. In a multivariate model, high frequency (4–7 days per week) of going to the lake (OR = 1.84,1.18–2.86, $P < 0.00$) remained associated with a heavy intensity of infection.

Spatial distribution of *S. mansoni* infection, wells and lake water contact points

The map of Musozi village showing the households of where PSC live showing distribution of *S.mansoni* infection, the lake water and well water contact points is shown in Fig. 1. The village has 12 boreholes/wells that are evenly distributed providing village members with easy access to well water; however, the water is used solely for drinking. The village also has 11 lake water contact points (*S. mansoni* infection sources) used to fetch water for other domestic needs including bathing.

Discussion

In the present study area, it appears that *S. mansoni* infection starts at an early age and is associated with various risk factors. This adds to the growing body of evidence that PSC can have schistosomiasis. The

Table 2 The distribution between the geometric mean intensity of infection in preschool children with *S.mansoni* infection in Musozi village by age and sex

Age category (years)	Male GMI (epg)	95 % CI	Female GMI (epg)	95 % CI	Combined GMI (epg)	95 % CI
1- < 2	283.9	25.5–2122.8	45.8	15.8–134.8	74.7	29.7–189.6
2- < 3	94.9	39.3–228.9	46.0	10.8–195.5	73.5	39.9–146.4
3- < 4	96.9	58.5–160.4	62.4	33.6–115.5	79.5	54.6–115.8
4- < 5	85.2	46.2–157.2	100.8	51.5–197.2	90.9	60.1–140.4
5- < 6	148.7	94.5–234	209.5	133.9–327.6	175.8	128.9–239.7
6- < 7	143.3	80.5–255	108.0	71.7–162.7	125.3	88.6–117.2

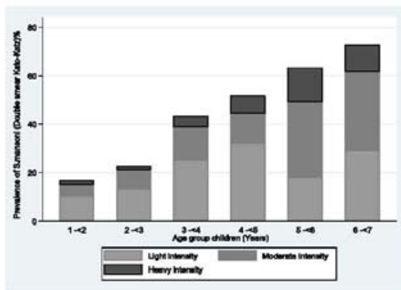

Fig. 4 Prevalence and intensities of *S. mansoni* based on Kato Katz technique among 383 pre-school children of Musozi villages, north-western Tanzania, stratified by age

prevalence was observed to vary by age groups but not by sex. Infections with *S. mansoni* were predominantly light, but moderate intensity and heavy intensity infections were increasingly becoming common from the age of 3 years. The main identified risk factors associated with *S. mansoni* infection in PSC were history of water contact and living at a distance of less than 500 m from the lake water contact point. A bathing frequency at the lake of 4–7 days per week was associated with a heavier intensity of infection.

The prevalence of egg patent *S. mansoni* infection was 44.39 % based on Kato-Katz, 45.85 % based on CCA when trace was considered as negative and 80.05 % on CCA when trace was considered as positive, of all the PSC who participated in the study. The prevalence estimates as determined by single stool double smear Kato-Katz and CCA with trace considered as negative (CCAt-) are broadly similar, however, the 35 % increment in prevalence observed when trace is considered as positive (CCAt+) is noted. It has been previously noted that when assessing the prevalence of *S. mansoni* using the CCA test alongside K-K, there is a higher 'true' prevalence with CCA than observed prevalence by K-K rather than the CCA test yielding a high number of false positives [33]. The 'traces' for this study could partly be accounted for by the fact that in this population most of the children have light infection as noted by the Kato-Katz, therefore, it is possible that the traces can be explained by pre-patent infections.

The overall prevalence of *S. mansoni* observed in this study was higher than that reported on the same age-group in Uganda on the shores of Lake Albert and Lake Victoria [45], in Usoma, Kenya [11] and in Ivory Coast [32] in West Africa. In addition, the overall geometrical mean in the present study was of moderate intensity and the majority of the children had light to moderate infection intensities. Only 6.53 % of the study participants most of them aged three years and above presented with heavy intensities. The intensity of *S. mansoni* infection was observed to increase with an increase in the age of the study participants. The results of the present study also show that there was no significant difference in intensity of infection by sex. This is likely due to a similarity of PSC's water contact behaviour and parents' or guardians' behaviour towards their children's water contact between the two sexes. As they grow older this similarity is lost as their behaviour towards water contact changes. This is affirmed by higher prevalence and

Table 3 Prevalence of infection with *S.mansoni* in pre-school children in Musozi village in relation to demographic characteristics water contact patterns and distance from the lake water contact point

Characteristic	No examined	No infected (Prevalence)	95 % confidence interval	χ2 *P* value
Sex				
Female	183	149 (81.42)	75.73–87.11	<0.73
Male	192	159 (82.81)	77.43–88.20	
Age (years)				
1-< 2	59	41 (69.45)	57.39–81.59	<0.00
2-< 3	75	51 (68.00)	57.19–78.80	
3-< 4	64	51 (79.69)	69.56–89.82	
4-< 5	54	50 (92.59)	89.38–99.80	
5-< 6	68	62 (91.18)	84.26–98.09	
6-< 7	55	53 (96.36)	91.25–101.47	
Go to the lake				
No	94	58 (61.70)	7.10–14.41	<0.00
Yes	279	249 (89.25)	85.58–92.90	
Mode of contact				
Never	97	59 (60.82)	50.94–70.71	<0.00
	255	227 (89.02)	85.16–92.88	
Accompanied				
Alone	21	21 (100)		
Frequency				
Never	206	148 (71.84)	65.65–78.04	<0.00
Moderate	59	51 (86.44)	77.44–95.44	
High	105	105 (100)		
Who				
Father	7	6 (85.71)	50.76–120.67	<0.68
Mother	89	85 (95.51)	91.11–99.89	
Self	10	10 (100)		
Guardian	6	6 (100)		
Sibling	49	46 (95.03)	86.92–100.83	
Distance				
≤ 500 m	146	117 (80.14)	73.58–86.68	<0.26
> 500 m	154	131 (85.06)	79.37–90.75	

Table 4 The factors associated with the prevalence of infection in preschool children in Musozi village Ukerewe district

Characteristic	Bivariate			Multivariate		
	OR	95 % CI	*P*-value	AOR	95 % CI	*P*-value
Sex						
Female	1			1		
Male	1.09	0.65–1.87	0.73	1.02	0.51–2.03	0.95
Age (years)						
1- < 2	1			1		
2- < 3	0.93	0.45–1.94	0.85	0.64	0.26–1.61	0.35
3- < 4	1.72	0.76–3.92	0.20	1.11	0.40–3.10	0.83
4- < 5	5.49	1.72–17.49	0.00	2.56	0.61–10.71	0.20
5- < 6	4.54	1.66–12.78	0.00	1.32	0.37–4.62	0.66
6- < 7	11.63	2.55–53.01	0.00	2.28	0.41–12.46	0.34
Go to the lake						
No	1			1		
Yes	5.15	2.94–9.04	0.00	2.31	1.06–5.01	0.03
Mode of contact						
Never	1					
Accompanied	5.22	2.96–9.20	0.00			
Alone						
Frequency						
Never	1			1		
Moderate	2.50	1.11–5.58	0.03	1.54	0.54–4.37	0.409
High						
Who						
Father	1					
Mother	3.54	0.34–36.8	0.29			
Self						
Guardian						
Sibling	2.56	0.22–28.67	0.45			
Distance						
> 500 m	1			1		
≤ 500 m	1.59	0.84–2.98	0.14	2.09	1.05–4.14	0.034

OR odds ratio, *AOR* adjusted odds ratio, *CI* confidence interval

Table 5 The relationship between the geometric mean of intensity of infection (GMI) in preschool children in Musozi village in Ukerewe North Western and the demographic characteristics

Characteristic	No infected	GMI	95 % CI	*P*-values
Sex				
Male	80	101.9	79.2–131.4	<0.41[a]
Female	90	118.9	93.7–150.8	
Age				
1- < 2	10	74.7	29.4–189.6	<0.00[b]
2- < 3	17	73.5	36.9–146.4	
3- < 4	29'	79.5	54.6–115.8	
4- < 5	29	91.9	60.1–140.4	
5- < 6	45	175.8	128.9–235.7	
6- < 7	40	125.3	88.6–177.2	
Go to the lake				
No	21	77.6	45.2–133.3	<0.00[a]
Yes	149	116.3	97–139.4	
Mode of contact				
Never	21	77.6	45.2–133.3	<0.00[b]
Accompanied	136	109.7	90.6–132.8	
Alone	13	213.6	124.4–366.6	
Frequency				
Never	57	75.7	55.2–104	<0.00[b]
Moderate (1–3)	33	93.5	66.9–130.5	
High (4–7)	76	117.9	117.9–193.8	
Who				
Father	5	101	46.3–220.5	
Mother	34	133.7	92–194.3	
Self	62	122.7	93.3–161.5	
Guardian	6	350.7	137.9–892	
Sibling	3	122	7.6–1967	
Distance				
> 500 m	70	123.1	92.8–163.1	<0.28[a]
≤ 500 m	71	108.9	83–142.9	

[a]Determined by *T*-test
[b]Determined by ANOVA

intensity of *S. mansoni* in males than females in school children. Similar findings were reported in Ivory Coast [32]. In comparison to studies conducted on the shores of the Lake Victoria in Uganda [45] and West Africa [32], the prevalence of heavy infection among PSC was higher in the present study. This could be due to the behavior of this population group especially those living 500 m from the lake and their repeated contact with contaminated water and lack of safe water for bathing and improved sanitation facilities. Adult individuals living in this particular setting have been repeatedly reported to be highly infected with *S. mansoni* and carry the highest intensities of infection [46, 47]. Increased water contact activities such as fishing, bathing and farming were associated with an increased risk of being infected with *S. mansoni* in the adult population [48].

One remarkable observation was that heavy infections were more common from the age of three years onwards where the prevalence was 4.4 % in 3-year-olds and 10.9 % in 6-year-olds. This has shown that young children can have heavy infections even at an age as young as 3 years old. It has been depicted that the heavier the infection the more severe the morbidity; however, even light egg patent infections [49, 50] and sub-egg patent

Table 6 The factors associated with log transformed egg counts in preschool children in Musozi village Ukerewe district North Western Tanzania

Characteristic	Bivariate			Multivariate		
	OR	95 % CI	*P*-value	AOR	95 % CI	*P*-value
Sex						
Female	1			1		
Male	1.16	0.83–1.64	0.38	1.17	0.83–1.65	0.13
Age (years)						
1- < 2	1					
2- < 3	0.98	0.41–2.34	0.97	0.94	0.39–2.24	0.88
3- < 4	1.06	0.47–2.36	0.87	0.98	0.43–2.26	0.97
4- < 5	1.23	0.55–2.73	0.60	1.10	0.47–2.56	0.81
5- < 6	2.35	1.10–5.03	0.02	2.05	0.90–4.69	0.08
6- < 7	1.67	0.78–3.62	0.19	1.49	0.65–3.41	0.33
Go to the lake						
No	1			1		
Yes	1.49	0.89–2.51	0.12	0.74	0.39–1.41	0.36
Mode of contact						
Never	1					
Accompanied	1.41	0.84–2.37	0.19			
Alone	2.75	1.26–6.00	0.01			
Frequency						
Never	1			1		
Moderate	1.23	0.76–1.98	0.38	1.30	0.77–2.19	0.30
High	1.99	1.36–2.91	0.00	1.84	1.18–2.86	0.00
Who						
Father	1					
Mother	1.20	0.26–5.57	0.80			
Self	1.21	0.46–3.21	0.69			
Guardian	1.32	0.48–3.60	0.58			
Sibling	3.47	0.97–12.34	0.05			
Distance						
> 500 m	1					
≤ 500 m	0.88	0.60–1.30	0.53			

infections are considered to be detrimental to well-being, especially in younger children [51, 52]. It is therefore important to focus on these children because they are set to suffer significant morbid effects as explained by King and Dangerfield-Cha [4] and mostly because it can take up to 3 years before they are treated.

Our study also examined the risk factors associated with *S. mansoni* infection in PSC, whereby the results show a significant association between the history of a visit to the lake and the infection with *S. mansoni* in this age group. Those who reported going to the lake had twice the odds of being infected with *S. mansoni* infection. This is supported by an observation made in western Kenya where reported water contact with the lake was associated with the infection with *S. mansoni* [53]. The distance from the water contact point was strongly associated with the infection with schistosomiasis, whereby, those who lived <500 m from the lake water contact point were at twice the odds of being infected with *S. mansoni* infection. It has been demonstrated that for this age group, the distance from the water point and the history of visiting the lake were significant factors for schistosomiasis infection. This is particularly important as lake water, which is the source of water for bathing and other domestic uses including drinking for some of the villagers, was continuously contaminated with *S.mansoni* eggs from the poor sanitation practice of defaecating in the lake water. This corroborates studies carried out in Western Kenya [53] and Tanzania [6] which found that the prevalence of infection decreases with the increase of the distance from the lake water shore. A history of a high frequency of bathing in lake water, (4–7 days) per week, was shown to be associated with a heavy *S. mansoni* infection where those who had high bathing frequency in lake water were at a 1.8 higher odds of heavy infection. Our present study is subject to limitation. The findings of this study only apply to the geographical setting where the study was undertaken and cannot be generalised to other geographical settings. The temporal relationship between some of the risk factors and the study outcomes could not be assessed due to the study design.

Conclusions

In conclusion, this study has demonstrated that the prevalence of *S. mansoni* in PSC in Musozi village in Ukerewe based on KK and CCAt- was moderate and high on CCAt+. It has also shown that moderate and heavy infections are common from the age of three years onwards. It is, therefore, important to consider including children of 3 years in PZQ-MDA programmes because they are set to suffer the significant morbid effects of chronic schistosomiasis. This study has also shown that going to the lake and living at a distance of ≤500 m to the lake were associated with a significant risk of being infected. It is important to provide health education for behaviour change to avoid contaminated water for the whole village community. Provision of safe water for the whole community for all domestic uses including bathing is also necessary. As efforts to develop and evaluate paediatric formulations of Praziquantel are underway, more studies to quantify the prevalence of *S. mansoni* infection in that particular age group should be carried out at the country level. Further investigation to quantify the morbidity due to intestinal schistosomiasis in this age group is recommended.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

DMR, RW, GMM were involved in the study design. DMR and HDM carried out data collection, analysis and manuscript preparation. DM critically reviewed the manuscript and the interpretation of the results. All authors read and approved the final manuscript.

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Appendix iv: Ethical clearance certificate.

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KEMRI/RES/7/3/1 **June 23, 2014**

TO: **DEODATUS RUGANUZA,**
PRINCIPAL INVESTIGATOR

THROUGH: **DR. KIMANI GACHUHI,**
ACTING DIRECTOR, CBRD
NAIROBI

Forwarded 28/7/14

Dear Sir,

RE: SSC PROTOCOL No. 2739 *(RESUBMISSION2)*: PREVALENCE AND INTENSITY OF INTESTINAL SCHISTOSOMIASIS AND THE ASSOCIATED FACTORS IN PRE-SCHOOL CHILDREN IN UKEREWE ISLAND, MWANZA REGION IN NORTH WESTERN TANZANIA. *(VERSION 1.1 OF 13TH JULY 2014)*

Reference is made to your letter dated 16th July 2014. The ERC Secretariat acknowledges receipt of the revised study protocol on 17 July 2014.

This is to inform you that the Ethics Review Committee (ERC) reviewed the documents submitted and is satisfied that the issues raised at the 226th meeting of the KEMRI ERC on 22nd April 2014 have been adequately addressed.

The study is granted approval for implementation effective this **23rd July, 2014**. Please note that authorization to conduct this study will automatically expire on **July 22, 2015.** If you plan to continue with data collection or analysis beyond this date, please submit an application for continuing approval to the ERC Secretariat by **June 10, 2015**.

Any unanticipated problems resulting from the implementation of this protocol should be brought to the attention of the ERC. You are also required to submit any proposed changes to this protocol to the SSC and ERC prior to initiation and advise the ERC when the study is completed or discontinued.

You may embark on the study.

Yours faithfully,

EAB

PROF. ELIZABETH BUKUSI,
ACTING SECRETARY,
KEMRI/ETHICS REVIEW COMMITTEE

In Search of Better Health