RISK FACTORS FOR *SCHISTOSOMA HAEMATOBIUM* INFECTION AMONG SCHOOL PUPILS IN AREAS RECEIVING ANNUAL MASS TREATMENT WITH PRAZIQUANTEL IN MOROGORO REGION, TANZANIA

By

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A dissertation Submitted in partial Fulfillment of the requirements for the degree of Master of Science in Parasitology and Medical Entomology of the Muhimbili University of Health and Allied Sciences

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CERTIFICATION

The undersigned certifies that he has read and hereby recommend for acceptance by Muhimbili University of Health and Allied Sciences a dissertation entitled **"Risk factors for *Schistosoma haematobium* infection among school pupils in areas receiving annual mass treatment with praziquantel in Morogoro region, Tanzania"** in fulfillment of the requirements for the degree of Master of Science in Parasitology and Medical Entomology of the Muhimbili University of Health and Allied Sciences.

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Date: 04 . 10 . 2010

DECLARATION AND COPYRIGHT

I, **Theresia E. Nkya**, declare that this dissertation is my own original work and that it has not been presented and will not be presented to any other University for similar or any other degree award.

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DEDICATION

This dissertation is dedicated to my beloved parents, Prof. Estomih Nkya and Honorable Dr. Lucy Nkya.

ABSTRACT

Introduction

There is a gap in the area of linking prevalence of *Schictosoma haematobium* infection, praziquantel benefits and associated risk factors together with behavior of the primary school pupils that expose them to infection. This has led to an increase in the urban transmission of *S. haematobium* causing urinary schistosomiasis; therefore, data from urban settings was needed to help in formulating and evaluating control policies and strategies.

Objective

This study aimed at determining the prevalence and intensity of *S. haematobium* infection among primary school children and associated risk factors in an area with annual administration of praziquantel in Morogoro municipality.

Methods

A cross sectional, stage wise random sampling survey of *S. haematobium* infection, factors influencing its transmission and praziquantel intake were studied among primary school pupils in Morogoro Municipality. A semi-structured questionnaire was used and urine from each pupil was collected in a plastic container and examined under a light microscope. Results were analyzed using SPSS version 12.0.

Results

The overall prevalence was 35.2% based on microscopic examination of urine sample. The proportion of students that did receive Praziquantel in the last general distribution was found to be 14.3% while 25.8% of the students had low infection intensity and 9.3% had high infection intensity. The contributing risk factors included playing in water, bathing in rivers, fishing in rivers and helping parents work in rice fields, were all found to be statistically significant (p –value<0.001) associated with *S. haematobium* infection.

Conclusion

The prevalence and intensity is high enough to cause re-infection. Still more effort is needed to enforce mass praziquantel administration among primary school pupils, alternative water sources for recreational activities, provision of proper latrines and further studies needed to explore the risk factors.

Recommendations

More effort should be directed at Morogoro municipal to restore the faith of community in mass administration of praziquantel. The factors that do put these children at risk, also needs to be further assessed and explored and more data needed so as to draw a reasonable conclusion that reflects the true population of the primary school children of Morogoro municipal. Pupils should also be instructed to correct personal habits which are conducive to infection and practice good personal hygiene can be an effective and safe substitute for repeated de-worming, reducing the opportunity for the emergence of drug-resistance, which should prolong the time anti-helminthic drugs such as praziquantel may be used for treatment of urinary schistosomiasis In addition, complementary integrated control activities, such as environmental management measures, should be planned with other sectors such as agriculture and water resource development programs. It is also important to ensure that any development activity likely to favor the emergence or spread of schistosomiasis and other parasitic diseases is preceded by a proper health impact assessment and accompanied by preventive measures to limit their impact

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DEFINITION OF TERMS

I. High intensity is defined as infection in which an individual is excreting 50 or more eggs of *S. haematobium* per 10ml urine sample

II. Low intensity is defined as infection in which an individual is excreting less than 50 eggs of *S. haematobium* per 10ml urine sample

III. Potential transmission sites are water contact sites frequented by the population but no intermediate hosts (snails) were sampled to find out if they shed cercariae

CHAPTER ONE

1.0 INTRODUCTION

Urinary schistosomiasis is caused by a parasite *Schistosoma haematobium*. Infection is acquired from water containing the larval forms (cercariae) of blood flukes, known as schistosomes.

The life cycle of *Schistosoma spp* takes place in three media, the definitive vertebrae host, the intermediate snail host and transmitting habitat. In the vertebrae host the sexual reproduction takes place in the vessels of the mesenteric or the vesical, in which the paired male and female worms can be found. *S. haematobium* do not directly reproduce within the human host but rather the female worm produces ample amounts of eggs, which are either voided in the host's urine or become trapped within tissues.

On reaching fresh water, egg may hatch and liberate a single miracidium, which is free living and in favorable water conditions it can survive up to 24 hours. During this period the miracidium is infective to the snail intermediate host only. While in the snail, the miracidium develop by metamorphosis to cercariae, which have a life span of about 48 hours and during which they are infective to humans.

The passage of eggs though the bladder perforates the bladder walls giving rise to the classic sign of infection, macrohaematuria (visible blood in the urine) due to the characteristic shape of the egg, having a terminal spine.

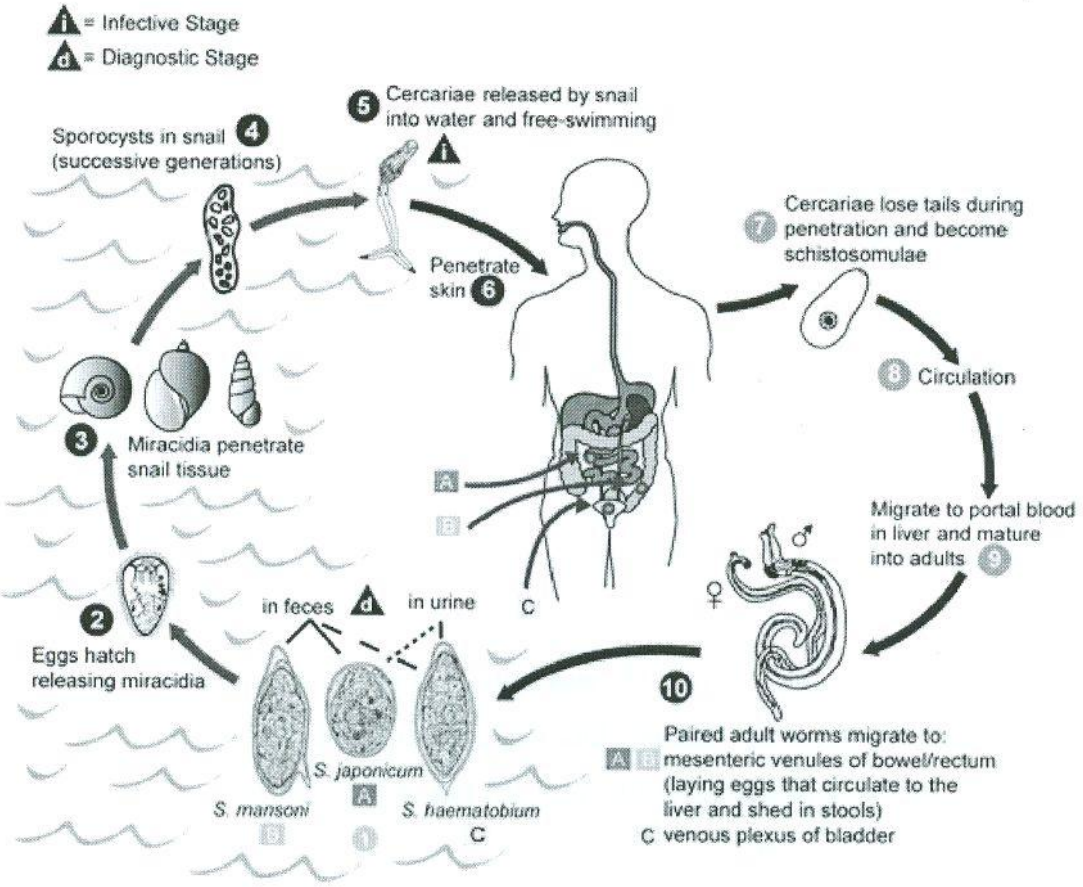


Figure 1: Life cycle of *Schistosoma spp* showing the infective stage and diagnostic stage. Labeled C represents *S. haematobium* specie that causes Urinary schistosomiasis. (Centre for Disease Control)

Epidemiology of *S. haematobium* infection

Schistosomiasis remains one of the most prevalent parasitic infections in the world. It is endemic in 76 countries and territories, and continues to be a global public health concern in the developing world (World Health Organization, 1993). It is particularly linked to agricultural and water development schemes. It is typically a disease of the poor who live in conditions which favor transmission and have no access to proper care or effective prevention measures (Engels et al 2002)

S. haematobium is found in tropical countries in Africa, the Caribbean, eastern South America, southeast Asia and in the Middle East. Iarotski and Davis (1981) determined that the most severely affected countries in Africa were Angola, Central African Republic, Chad, Egypt, Ghana, Madagascar, Malawi, Mozambique, Nigeria, Senegal, Sudan, the United Republic of Tanzania and Zambia. To these should be added Mali, Uganda and Zimbabwe (Taylor and Makura, 1985; Kabatereine *et al*., 1992, Ndhlovu *et al*., 1992; Bukenya and Nsungwa, 1994; Traore *et al*., 1998).

The disease is endemic in developing countries, infecting more than 200 million people, half of whom live in Africa. In many areas, urinary schistosomiasis infects a large proportion of children under 14 years of age, (Chistulo *et el* 1995). In sub-Saharan Africa, where the greatest burden of the disease is found, some 70 million individuals are estimated to have haematuria and of these, approximately 32 million suffer from dysuria with 18 and 10 million having severe bladder wall pathology and hydronephrosis, respectively (Van Der Werf and De Vlas, 2004).

The Molluscan intermediate host

In the *S. haematobium* lifecycle, the intermediate host is a snail. The intermediate host is specie specific meaning that *Schistosoma spp* infects specific snail specie and these snail species vary from one endemic area to another. The snail host is infected by the miracidium via its soft tissue. In Tanzania the principle snail host for *S. haematobium* is *Bulinus (physopsis) nasutus, B. africanus and B. globosus* (McCulogh 1972 and

Brown 1980). Although many other *Bullinus spp* have been identified in the country but the above mentioned are of the most importance for *S. haematobium* transmission.

The efficacy of the snail host depends on their population density in the habitat, adaptation to the local environment, sensitivity to, and ability to with stand schistosoma infection. Thus a good snail host has to be susceptible to schistosoma strain, reproduces rapidly to maintain a large population in the habitat and in order to withstand unfavorable environmental conditions, it should be able to aestivate (Rugemalila, 1991).

1.2 LITERATURE REVIEW

Prevalence and control of *S. haematobium* infection

As there is little accurate data on country specific prevalence, global estimates for the number of people infected and number at risk of infection must still be made based on calculations of limited prevalence survey data at the country level. The most accurate data may be those provided by national control programmes or from national surveys. National surveys have been conducted in a few countries in Africa with estimates of national prevalence given (Engles et al., 2002). When prevalence data were calculated and applied to the 1995 population estimates, it was calculated that about 652 million people are at risk of infection from the five human *Schistosoma spp* and that 193 million are infected. Based on these calculations, 85% of the estimated numbers of infected people are currently on the African continent (Chitsulo *et al*., 2000). A review study suggested that the number of deaths in Sub-Sahara Africa involving urinary schistosomiasis in sub-Saharan Africa may be as high as 200000 per year (Van der Werf *et al.,* 2002)

The control of schistosomiasis deserves more and renewed attention and commitment, particularly in sub-Saharan Africa. The 1984 World Health Organization Expert Committee on the Control of schistosomiasis introduced a strategy for morbidity control, which had become feasible because of the availability of effective and safe single dose

of praziquantel (WHO, 1985). Community wide treatment campaigns were initiated in numerous endemic areas, Tanzania included.

Praziquantel the drug of choice for all forms of schistosomiasis has become significantly less costly (Doenhoff *et al.*, 2000; Appleton and Mbaye, 2001). Community-based treatment is first targeted to school-age children. There is indeed evidence that the impact of treatment on morbidity decreases with age, and that repeated treatment in the early stages of life has a long-lasting effect on morbidity at a later age.

In this perspective, focusing the delivery of regular chemotherapy on the younger age groups will produce maximum benefits, and prevent chronic sequel in adulthood (King et al., 1992; Hatz *et al.*, 1998; Frenzel *et al.*, 1999). School-age children can be reached through the primary school system, in collaboration with the educational sector. Even in areas where school enrolment rates are low, outreach activities can be designed to ensure good coverage (Montresor *et al.*, 2001). It also implies that presumptive treatment, on the basis of early clinical symptoms, or universal treatment on the basis of epidemiological criteria, have become cost-effective in an increasing number of endemic situations (Guyatt *et al.*, 1994; Carabin *et al.*, 2000). As Praziquantel is a safe drug, it can be delivered at the most peripheral levels of the drug delivery system, also by non-medical personnel.

The deteriorating socio-economic situation, a progressive loss of diagnostic potential in peripheral health facilities, and the appearance or reemergence of more visible health problems, may have contributed to the downgrading of schistosomiasis on the public health agenda. The fact that schistosomiasis is a focal problem, of which the public health importance is 'diluted' at the national level, may have further been responsible for the decreasing commitment towards its control by national health authorities(Engles *et el.*, 2002).

Transmission factors of *S. haematobium* infection

Various socio-epidemiological factors are responsible for transmission of the disease and level of infection. Among such factors are the following: distance from transmission site, migration and emergence of new foci, urbanization, socio-economic status, sanitation, water supply patterns and level of urine contamination of water source (Bareto, 1986). This waterborne tropical disease is strongly associated with populations living in poverty (Engels and Savioli 2006) since infections are acquired by exposure to unsafe environmental water infested with schistosome larvae. Parasitological diagnosis of the disease is usually based upon the observation of schistosome egg of mid-morning urine (Compton and Savioli, 2006)

Transmission of urinary schistosomiasis occurs when the infected person urinates in the water bodies which serve as source of drinking or bathing, thereby introducing eggs which hatch into larva that infect the snail hosts. This can only be controlled by the provision of latrines and urinals or the introduction of effective sewage disposal systems. The provision of safe swimming pools for recreational activities could serve as a good control measure for the spread of the disease (Gracio, 1992). Wearing of footwear to protect the legs could also be a good protective measure against active penetration by the cerceriae of the schistosoma (Amano *et al.*, 1990)

It is still necessary to understand both physical and molluscan aspects of transmission for, as people travel, the place at which infections were encountered does not always correlate, or best predict, the actual place where infections were initially or subsequently acquired. It is this peculiarity where the distribution of the snail, and not man, actually restricts, in time and space, the active disease transmission zone to people (Stothard *et al.*, 2002).

In studies such as the one done in Nigerian primary schools, both the prevalence and intensity of infection were found to be highest in children aged 10± 14 years (Ejezie *et al.*, 1981). The high prevalence often seen in this age-group are probably linked to high levels of water contact and exposure to cercariae (Dalton and Pole, 1978), a view supported by the present observations. In endemic areas, recreational water activities

such as bathing, swimming and playing in water carry particularly high risks of infection (Lwihula, 1987) since they involve prolonged and almost total immersion of the body. Other activities may require only brief exposures of the hands and/or feet.

1.3 PROBLEM STATEMENT

Over the current years, there has been mass administration of praziquantel to school pupils in Morogoro region as one of the strategies to control urinary schistosomiasis. Yet prevalence and intensity of urinary schistosomiasis in Morogoro municipality is not available. The last research assessing the prevalence and intensity of urinary schistosomiais (*S .haematobium* among primary school pupils) in Morogoro was in 2004. In 2008 there was a mass administration of praziquntel, yet no follow up evaluation was done. The risk factors associated with schistosomiasis transmission; potentially infected water with cercariae and inadequate sanitation and hygienic practices continue to supplement the circle of re-infection and no studies have been carried out to reassess their role in transmission.

There was a gap in the area of linking praziquantel benefits and associated risk factors together with behavior of the school children that expose them to infection. This has led to an increase in the urban transmission of parasites causing urinary schistosomiasis. Fresh epidemiological data from urban settings needed to help in formulating and evaluating control policies and strategies.

The current data was generated to address this gap and look at how beneficial praziquantel has been in the study area

1.3.1 Rationale of the research problem

Some progress has been made towards attaining the national and international targets to mass praziquantel administration among school age children in Tanzania mainland, but that alone has not be effective since most data on prevalence and transmission of schistosomiasis at local level has not available. Also a link between the benefits of taking praziquantel and re-infection together with associated risk factors should be

thoroughly assessed so as to come up with proper control policies and strategies. This research seeks to contribute towards an understanding of the prevalence and intensity of urinary schistosomiasis and factors associated with its transmission.

The study in collaboration with other studies, can give a clue to advise the Ministry of Health and Social Welfare, Ministry of Education and Vocational Training and other stake holders on the way forward towards controlling schistosomiasis. Generally this study will help to improve the ongoing National Schistosomiasis and Soil-transmitted Helminthes Control Programme (NSSCP).

1.4 OBJECTIVES

1.4.1 Broad objective

To determine the prevalence and intensity of *S. hematobium* infection among primary school children and associated risk factors in an area with annual administration of praziquantel in Morogoro municipality

1.4.2 Specific objectives

1. To determine the prevalence of *S. hematobium* infections among school pupils in Morogoro municipality
2. To determine the intensity of *S. hematobium* infection among primary school pupils in Morogoro municipality
3. To determine the proportion of primary school children who received praziquantel in 2008
4. To explore urination practices that may facilitate transmission of *S. haematobium* among primary school pupils in Morogoro municipality
5. To explore activities that may predispose school children to come into contact with potentially infected water bodies in the study area
6. To determine percentage of primary school children with *S. haematobium* eggs in their urine and how this relates to haematuria

CHAPTER TWO

2.0 RESEARCH METHODOLOGY

2.1 Study area

The study was concentrated in Morogoro municipality with an estimate of 206,868 people (Bureau of statistics, 2002). Morogoro was selected because it's among regions endemic with *S. haematobium* infection in Tanzania with a high prevalence of 86%. Also, pupils in this area were administered praziquantel in 2008 that had severe side effects that caused many parents in the area to refuse their children from receiving praziquantel in subsequent administrations.

In general the hot season runs from July to September. Morogoro municipal is relatively well supplied with water resources. The population has a variety of water sources including, Shallow wells, constructed or improved traditional pipe water systems, streams and rivers, dams, and bore holes.

2.2 Study design

This was a Cross-sectional study in which a semi structured questionnaire was used to generate information from the school children about visible haematuria, water contact patterns, hygiene or sanitary practices and praziquantel intake. A urine sample was collected to determine eggs and microhaematuria for prevalence and intensity.

2.3 Target and study population

The target of the study population was the primary school pupils of all age groups from the public primary schools in the Morogoro municipality.

2.4 Sample size estimation

Ten out of fifty six primary schools were multistage random sampled in which a minimal number of 778 was required to be sampled. A total of 884 students ended up being sampled.

The minimum sample size was obtained using the following formula: -

$$n = (1.96/ w)^2 p (1-p)$$

Where: n = sample size (minimum sample size)

W = margin of error on P (3%) = 0.03

p = the highest prevalence of *S. haematobium* that had been found to infect primary school children in the study area (86%) = 0.86.

Therefore; $n = (1.96/0.03)^2 \ 0.86(1-0.86) = 512$

This was a stage wise random sampling, therefore calculated variance inflation factor (f) which is 1.5:

514(f) = 514 * 1.5 = 768, when added 10% for missing data, dropout or non response the sample size was 845

The minimum calculated sample for this study was 845 primary school pupils. We interviewed 884 pupils from ten schools.

2.5 Recruitment of research assistants

Two research assistants with interview skills and medical background were recruited and given orientation to the study for two days. Logistic arrangements were also made.

2.6 Sampling procedure

Two stage random sampling was used to select participants who were interviewed using semi-structured questionnaire. During sampling, a sampling frame of all public primary schools located in the municipality was obtained from the municipal education officer.

Using a list of all public primary schools in the municipality, the name of each of the primary schools in the municipal was written on a separate piece of paper then assembled together in one box for sampling. A simple random sampling was applied by picking ten pieces of paper with the name of ten primary schools.

After selecting the schools, names of pupils were obtained from the daily attendance book by random sampling. The reason this was done was to show a true representative sample and no bias, whereby the students that were not present in school at the sampling day, were also included in the survey.

2.7 Study instruments

In this study urine sample were collected for parasitological examination. In order to accomplish these measurements the following items were secured; a screw caped plastic container with an identification number which was used to collect urine samples.

2.8 Study procedures

2.8.1 Pre-testing

Prior to commencing the study, questionnaires were pre tested in Mlimani primary school to check if the questions were well understood, if the sequence of the questions was logical and if there was a need for any modification in terms of structuring or rephrasing the questions. Thereafter amendments of the questionnaire were made. The questionnaire was then used for final data collection.

2.8.2 Data collection

Baseline data was obtained from a survey done in 2004 by the Office of the Morogoro Regional Medical Officer, which looked at the prevalence of urinary and intestinal schistosomiasis among school pupils in Morogoro Municipality. This baseline data explored parasitological results of primary school in Morogoro region. The survey results showed an overall prevalence of 86% for urinary schistosomiasis among the pupils from Morogoro region respectively.

Research instruments/tools were used to generate qualitative as well as the quantitative data. During data collection school teachers were asked to mobilize pupils while the research assistants instructed pupils on how to fill urine sample in a provided container with urine sample.

A semi-structured questionnaire was used to generate quantitative data from the pupils in which research assistants filled the questionnaires under supervision of the principal investigator. Information collected by the research assistant was validated by principal investigator in the field by checking each questionnaire.

2.8.3 Collection of quantitative data (urine samples)

Immediately after interviewing the pupils the next step was to collect urine specimens in which screwed plastic containers marked with an identification number were provided to each of the sampled pupil to collect fresh urine sample.

Pupils were instructed to collect about 10 milliliters of fresh urine specimens respectively. Once the urine specimen was received about 2ml of 10% formaldehyde was added to the specimen to fix the worm's eggs and preserve the urine. Urine samples were stored at room temperature.

2.8.4 Parasitological examination

Ten pupils at a time were allowed at once to go for urine sample collection to make sure that they did not find opportunity to share their urine samples. The students received thorough instructions from the principal investigator on how to collect sufficient amount of urine. Urine samples were collected between 10.00am and 2.00pm a convenient time for high egg output. The collected urine sample was mixed with drops of formalin to prevent bacteria growth and eggs hatching then were placed in a cold box immediately after collection. The samples were taken to the laboratory for examination in the same day.

At the laboratory, 10mls of urine was syringed and filtered using a 25mm diameter filter holder and a nucleopore filter with a 12µm pore size. The filter then was placed on a glass slide for quantitative examination of *S. haematobium* eggs under light microscope(x40 objective lens). Those found with one or more eggs were recorded as infected and the number of *S. haematobium* eggs present in each preparation were counted and recorded

2.8.5 Collection of qualitative data

Qualitative data was generated using questionnaires (Appendix II) in which the primary school pupils were in-depth interviewed. This took place in a designated classroom under the supervision of the principal investigator.

2.8.6 Data management and analysis

Data was edited during and after data collection, coded and classified to adjust for any missing information and collection of outliners. The primary data (qualitative and

quantitative data) was entered by two people, the principal investigator and the data clerk using SPSS Version 12.0.

Frequency tables and cross tabulation were produced where appropriate and a logistic regression model was applied to identify explanatory variables that has significant role in influencing dependent variables. Moreover, association was made for the independent and dependent variables using chi-square test and significance level set at p= 0.05.

2.8.7 Ethical clearance

Ethical clearance was obtained from the Muhimbili University of Health and Allied Sciences (MUHAS) Ethical Review Board (Appendix V). Permission to conduct the study in Morogorogo municipality was obtained from the municipal education officer who issued a written permission to the sampled schools. A verbal consent was obtained from the participants the same day they were interviewed.

The aim of the research, their usefulness in the community as well as the role of participants during the survey was explained. Participants were assured for confidentiality of the information collected. In order to maintain confidentiality questionnaires were treated anonymously (i.e. no names but code numbers were used) and answers to questions including the results for the urine samples were handled carefully to restrict unauthorized access.

The participants were informed that the survey must abide with ethical guidelines in which the end use of the biological sample after the study has reached the end must follow ethical guidelines indicated by the Muhimbili University of Health and Allied Sciences research and ethics committee.

Participants were also informed about their voluntary participation allowed to decide on their own whether to participate or not. Withdraw from the study was the right of participant. After reaching agreements between the participants and the research assistant/principal investigator, participants were asked to sign the consent form as per

MUHAS requirements. Once the consent had been signed, the interview began. The principal investigator supervised the whole process to ensure voluntary participation in the study.

During the survey arrangements were made with the nearest public health center or dispensary for the possibility of treating children who were found to have urinary schistosomiasis. St. Mary's hospital located in Morogoro volunteered to treat each student that was found to have urinary schistosomiasis

The findings of the study will be communicated to the Morogoro Municipal Medical Officer, the District Education Officer, the Ministry of Health and Social Welfare through National Schistosomiasis and Soil Transmitted Helminth Control Program (NSSCP), the Ministry of Education and Vocational Training in Tanzania and other relevant stake holders.

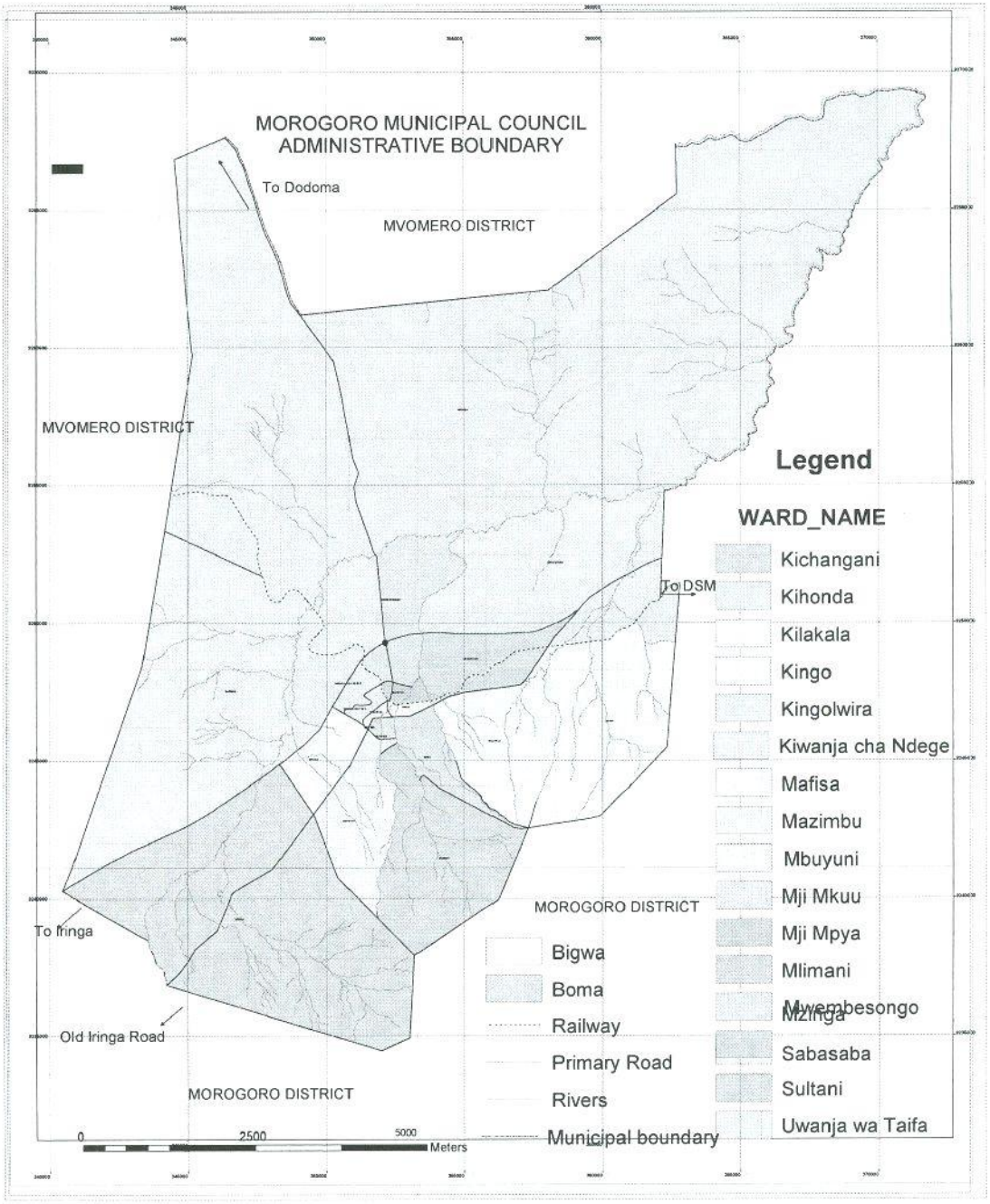
CHAPTER THREE

3.0 RESULTS

3.1 Background characteristics of the study area

The main water body identified in the area was Morogoro river. This river runs across the study area (Map 1). This was considered as a potentially infected water body even though there were no snails sampled from this river in the study. The river was observed to have vegetations. There were sewage systems that were observed to have outlets into the river and the major human water contact sites were identified.

Water contact sites were observed to be regular swimming, bathing, fishing and crossing points for the pupils. Other various points on the river were used for washing, and collecting water for gardening. Other sites were not fully observed due to poor infrastructures and other sites were not used at all by people.



Map 1. A map of Morogoro Municipality showing sampled schools

3.2 Demographic characteristics

The study involved a total of 884 pupils who were interviewed and their urine screened for *S. haematobium* infection. In the schools sampled, large majority of students were from Kilakala primary school (16%) (Table 1).

Table 1: Distribution of pupils according to their schools. (N=884)

Name of school	N (%)
Bungo	117 (13.20)
Chamwino	133 (15.0)
Kilakala	141 (16.0)
Kiwanja cha Ndege	70 (7.9)
Mchikichini	75 (8.50)
Mkwajuni	64 (7.2)
Mtawala	70 (7.9)
Mwembesongo	63 (7.1)
Mwere	90 (10.20)
Uhuru	61 (6.9)

All school children sampled were from standard one to standard seven, females were 459 (51.9%) and males 425 (48.1%) with a mean age of 10.9 years for Males and 10.6 years for Females. Males had a higher standard deviation (2.42) from their mean age compared to female's standard deviation (1.70). Males where 425 (48.1%) and females were 459 (51.9%). (Table 2).

Table 2: Mean age of pupils in the study

Sex of pupil	Mean age	Number of pupils	Std. Deviation
Male	10.92	425	2.42
Female	10.61	459	1.70

3.3 Prevelence of *Schistosoma haematobium*

The overall prevalence rate of *S. haematobium* infection was found to be 32.5% in the ten schools that were sampled. Among all pupils sampled, 287 pupils out of 884 (95% CI, -3.1, 35.6%). (Table 3)

Table 3: Prevalence of *S. haematobium* infection in the study area. (N=884)

Pupil's sampled urine	Prevalence	95% Confidence Intervals
Eggs found in Urine	287 (32.5%)	-3.1%, 35.6%

The prevalence was then observed by school, where by the results showed that Kilakala primary school had the highest prevalence (43.97%) followed by Mwembesongo (42.86%) while Mchikichini primary school (22.67%) had the lowest prevalence. (Table 4)

Table 4: Prevalence of *S. haematobium* by school. (N=884)

Name of school	With eggs n (%)	Without eggs n (%)
Mchikichini	17 (22.67)	58 (77.33)
Mwere	29 (32.22)	61 (67.78)
Mtawala	30 (42.86)	40 (57.14)
Mkwajuni	21 (32.81)	43 (67.19)
Chamwino	32 (24.06)	101 (75.94)
Bungo	27 (23.08)	90 (76.92)
Kilakala	62 (43.97)	79 (56.03)
Mwembesongo	27 (42.86)	36 (57.14)
Kiwanja cha Ndege	19 (27.14)	51 (72.86)
Uhuru	23 (37.7)	38 (62.3)
Total N (%)	**287 (32.5)**	**597 (67.5)**

Furthermore, prevalence by age was calculated and the results showed that, pupils in age group 9 to 11 years old had the highest prevalence of 51.22% compared to any other age group (Table 5).

Table 5: Prevalence of *S. haematobium* infection by age. (N=884)

	Age groups			
	6-8 years	9-11 years	12-14 years	15-16 years
With eggs in urine	35 (12.20%)	147 (51.22%)	100 (34.84%)	5 (1.74%)
Without eggs in urine	65 (10.89%)	328 (54.94%)	186 (31.16%)	18 (3.02%)
Total	**100 (11.31%)**	**475 (53.73%)**	**286 (32.35%)**	**23 (2.60%)**

Prevalence was again analyzed by sex. Here male pupils had the higher prevalence of 50.17% compared to female pupils that had a prevalence of 49.83%. (Table 6)

Table 6: Prevalence of *S. haematobium* by sex. (N=884)

	Sex of Pupil	
	Male	Female
With eggs in urine	144 (50.17%)	143 (49.83%)
Without eggs in urine	281 (47.07%)	316 (52.93%)
	425 (48.08%)	459 (51.92%)

The relationship between pupils that urinated blood in the past one year and those that were found to have *S. haematobium* eggs in the urine was then analyzed. Few pupils (27.83%) urinated blood in the past one year and had eggs in their urine. The odds ratio was found to be 16.11, meaning pupils that had urinated blood prior to the survey were 16.11 times more likely to have eggs in their urine compared to those that did not urinate blood within the past one year. This was found to be statistically significant (95%CI 11.06%, 23.28%, p-value <0.001) (Table 7).

Table 7: Relationship between pupils that urinated blood with in the past year and have *S. haematobium* eggs in their urine. (N= 884)

	Laboratory results		
	S.haematobium eggs in urine	Odds ratio	95% Confidence intervals
Urinated blood in the past	246 (27.83%)	16.11	11.06 - 23.48

p-value<0.001

3.4 Intensity of *S. haematobium* among school pupils

It was observed that 228/884 (25.8%) of the pupils had low infection intensity and 82/884 (9.3%) had high infection intensity. The intensity was analyzed according to schools and it was found that Kilakala primary had more pupils (33.33%) with low infection intensity compared to the other sampled schools, while Mwembesongo had more pupils (23. 81%) with high infection than any other sampled schools. (Table 8).

Table 8: Intensity of *S. haematobium* infection according to schools sampled (N=884)

Name of School	Low infection n (%)	High infection n(%)	No infection n (%)
Mchikichini	15 (20)	2 (2.67)	58 (77.33)
Mwere	26 (28.89)	3 (3.33)	61 (67.78)
Mtawala	15 (21.43)	15 (21.43)	40 (57.14)
Mkwajuni	7 (10.94)	15 (23.44)	42 (65.63)
Chamwino	27 (20.3)	4 (3.00)	102 (76.69)
Bungo	23 (19.66)	4 (3.42)	90 (76.92)
Kilakala	47 (33.33)	16 (11.35)	78 (55.32)
Mwembesongo	12 (19.05)	15 (23.81)	36 (57.14)
Kiwanja cha Ndege	14 (20.00)	6 (8.57)	50 (71.43)
Uhuru	42 (68.85)	2 (3.28)	17 (27.87)
	228 (25.79)	**82 (9.28)**	**574 (64.93)**

When intensity was analyzed by age, the results showed that the age group of between 9 to 11 years old had the highest intensity (53.73%) of *S. haematobium* infection compared to any other age group and for those pupils that were between 15 and 16, had the lowest intensity of infection (2.6%). (Table 9)

Table 9: Intensity of *S. haematobium* by age. (N=884)

	Age groups			
	6-8 years	9-11 years	12-14 years	15-16 years
Low infection	24 (10.53%)	124 (54.39%)	76 (33.33%)	4 (1.75%)
High infection	13 (15.85%)	44 (53.66%)	24 (29.27%)	1 (1.22%)
No infection	63 (10.98%)	307 (53.48%)	186 (32.4%)	18 (3.14%)
	100 (11.31%)	**475 (53.73%)**	**286 (32.35%)**	**23 (2.6%)**

Furthermore, intensity was then calculated by age and the results showed that females had the higher intensity of 51.92% of *S. haematobium* infection compared to males that had intensity of 48.08%. (Table 10)

Table 10: Intensity of *S. haematobium* infection by sex. (N=884)

	Sex of respondent	
	Male n(%)	Female n(%)
Low infection	112 (49.12)	116 (50.88)
High infection	47 (57.32)	35 (42.68)
No infection	266 (46.34)	308 (53.66)
	425 (48.08)	**459 (51.92)**

3.5 Urinating habits of primary school pupils

Pupils that swim in rivers were asked if they urinated in water while swimming. This was analyzed by age and the results showed that pupils between 9-11 ears old had the highest proportion of urinating in the river (51.22%) than any other age group. (Table 11)

Table 11: Urination habits of pupils when they go swimming in river by age. (N=884)

When you go swimming in river where do you urinate?	Age groups			
	6-8 yrs	9-11 yrs	12-14 yrs	15-16 yrs
Urinate out of water	12 (11.54%)	61 (58.65%)	29 (27.88%)	2 (1.92%)
Urinate in water	23 (12.57%)	86 (46.99%)	71 (38.79%)	3 (1.64%)
	35 (12.2%)	**147 (51.22%)**	**100 (34.84%)**	**5 (1.74%)**

Furthermore pupils were asked where they defecate if toilets were not available at home or school. The answers where analyzed and majority (2.38%) of pupils urinated in rivers (Table 12).

Table 12: Alternative areas pupils urinate when are not available at home or school

If toilets are not available what where else do you defecate?	
	N (%)
Bushes	12 (1.35)
Rivers	21 (2.38)
Streams	4 (0.45)
Farms	6 (0.68)
Elsewhere	841 (95.14)
Total	884 (100)

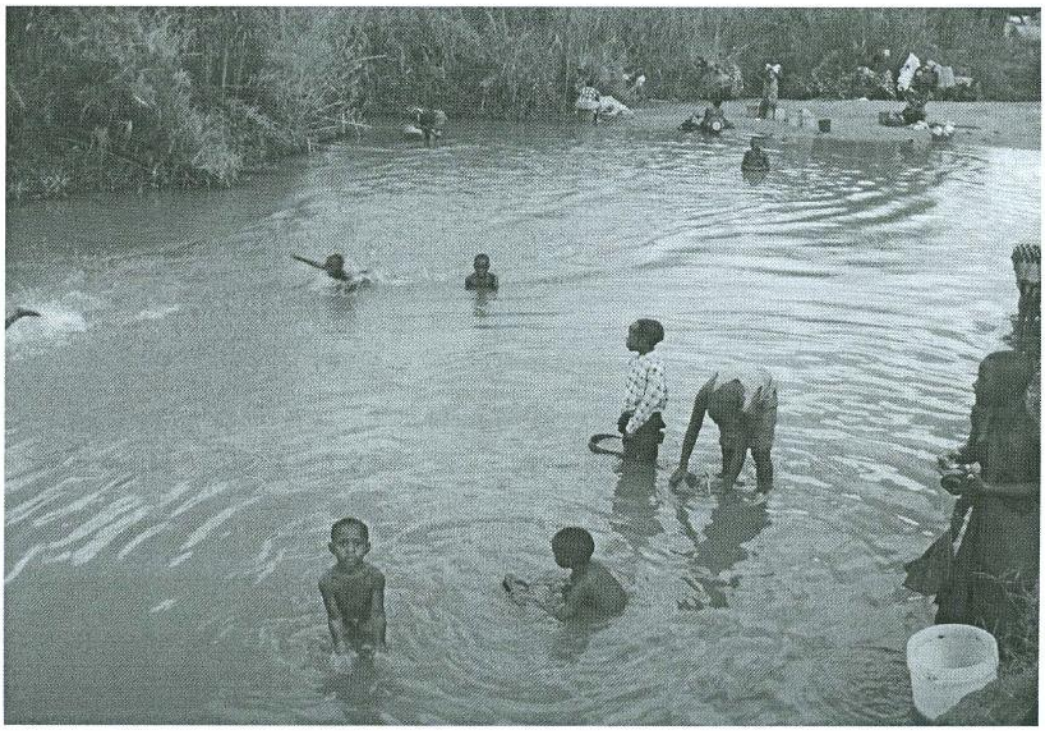
3.6 Risk factors for *S. haematobium*

The risk factors where then observed to see if they contributed in putting a pupil at risk of having *S. haematobium* infection. For those pupils that bath in rivers, ponds, dams or streams were 7 times more at risk of being infected with *S. haematobium* than the pupils that did not bath in the water bodies. The pupils that played in water were 3.7 more times at risk with being infected than those pupils that did not play in water. And those who went fishing, were 4 times more at risk of being infected with the parasite that those that did not fish. These above mentioned risk factors are statistically significant since their 95% confidence intervals did not include 1. (Table 13)

Table 13: Relationship between Risk factors of *S. haematobium* and eggs in pupil's urine

Variable	*Schistsoma haematobium* eggs		Total	OR	95% CI
	Yes	No			
Sex of respondent					
Male	144 (50.2%)	281 (47.1%)	425 (48.1%)	1.1	(0.9, 1.5)
Female	143 (49.8%)	316 (52.9%)	459 (51.9%)		
Did you take praziquatel in the last annual drug distribution					
No	252 (87.8%)	506 (84.8%)	758 (85.7%)	1.3	(0.8, 2.0)
Yes	35 (12.2%)	91 (15.2%)	126 (14.3%)		
Do you like playing in water (not necessarily swimming)					
Yes	186 (64.8%)	197 (33.1%)	383 (43.4%)	3.7	(2.7, 5.1)
No	101 (35.2%)	399 (66.9%)	500 (56.6%)		
Do you bath in rivers, ponds, dams or streams					
Yes	224 (78.0%)	202 (33.8%)	426 (48.2%)	7.0	(5.0, 9.8)
No	63 (22.0%)	395 (66.2%)	458 (51.8%)		
Do you go fishing					
Yes	71 (24.7%)	45 (7.5%)	116 (13.1%)	4.0	(2.6, 6.2)
No	216 (75.3%)	552 (92.5%)	768 (86.9%)		
Do you help your parents to work in rice fields					
Yes	67 (23.3%)	104 (17.4%)	171 (19.3%)	1.4	(1.0, 2.1)
No	220 (76.7%0	493 (82.6%)	713 (80.7%)		

Rist factors were observed in the study site (Picture 1) which included swimming, fetching water, washing clothes, bathing and playing in water. The students carried out these activities as part of their daily routine, however even grown ups were observed to be in contact with the water body. This point in the Morogoro river is famous for such activities and many parents that allow their children to carry out these activities. The depth is shallow and hence attributing to the opinion that the water body is safe since there has been no drawning incidence. (Personal observation)



Picture 1:Children swimming and carrying out various activities in Morogoro river.

3.7 Primary school pupils carrying *S. haematobium* eggs and have haematuria

Pupils who had *S. haematobium* infection in their urine were then analyzed for macrohaematuria and microhaematuria. The total number of pupils that had *S. haematobium* infection was 287, where by 116 (40.42%) of them had macrohaematuria. (Table 14)

Table 14: Proportion of pupils with macrohaematuria and have *S. haematobium* infection

Macrohaematuria	N (%)
Present	116 (40.42)
Absent	171 (59.58)
Total	287 (100)

For microhaematuria, the results showed that 276 (96.17%) of pupils that have *S. haematobium* infection also had red blood cells in their urine, which is an indicator of microhaematuria (Table 15)

Table 15: Proportion of pupil's with microhaematuria and has *S. haematobium* infection

Microhaematuria	N (%)
RBCs present	276 (96.17)
RBCs not present	11 (3.83)
Total	287 (100)

Furthermore, haematuria was observed according to age. For macrohaematuria, it was found students whose age ranged from 9 to 11 years had microhaematuria of 51.73%, which that was the highest among all age groups. (Table 16)

Table 16: Macrohaematuria by age among pupils with *S. haematobium* infection

Macrohaematuria	Age groups in years (%)			
	6-8	9-11	12-14	15-16
Present	8 (6.90)	60 (51.72)	47 (40.52)	1 (0.86)
Absent	27 (15.79)	87 (50.88)	53 (30.99)	4 (2.34)
	35 (12.20)	147 (51.22)	100 (34.84)	5 (1.74)

Microhaematuria was also analyzed by age and the results showed that the pupils in the age group between 9 to 11 years old had the majority of red blood cells in their urine (50.36%) and the age group of 15 to 17 years had the least cases of red blood cells in urine. (Table 17)

Table 17: Microhaematuria by age among pupils with *S. haematobium* infection

Microhaematuria	Age groups in years (%)			
	6-8	9-11	12-14	15-16
RBCs present	34 (12.32)	139 (50.36)	98 (34.51)	5 (1.81)
RBCs not present	1 (9.09)	8 (72.73)	2 (18.18)	0 (0)
	35 (12.20)	147 (51.22)	100 (34.84)	5 (1.74)

3.8 Praziquantel uptake among pupils in the study area

Out of the 884 students sampled, 126 (14.3%) took praziquantel in the last annual distribution and 758 (85.7%) did not take praziquantel. (Table 18)

Table 18: Sex of pupils who took praziquantel in the last annual administration. (N=884)

Sex	Did you take Praziquantel in the last general distribution?	
	Yes (n %)	No (n %)
Male	56 (13.2)	369 (86.8)
Female	70 (15.3)	389 (84.70)

The relationship between those pupils that received praziquantel in the last general administration and those who have *S. haematobium* infection was observed. Whereby 3.96% of pupils received praziquantel in the last general administration and also had *S. haematobium* infection with an odds ratio of 0.77, however this was not statistically significant (95% CI 0.5, 1.2). (Table 19)

Table 19: Relationship of praziquantel intake with presence of *S. haematobium* eggs in pupil's urine. (N=884)

S.haematobium eggs	Praziquantel uptake			
	Yes (%)	No (%)	OR	95% CI
Absent	91 (10.29)	506 (57.24)	0.77	0.5, 1.2
Present	35 (3.96)	252 (28.51)		

CHAPTER FOUR

4.0 DISCUSSION

This study was undertaken two years after the last mass distribution of praziquantel to primary school pupils of Morogoro municipality in 2008. At this time all pupils and teachers were aware of the praziquantel administration and effort put into controlling urinary schistosomiasis.

4.1 General characteristics

Schools sampled were ten and from each school the number of pupils sampled varied. Data was collected during end of term examinations hence led to collection of unequal number of samples from each school. Many pupils sampled were females 459 (51.9%) with a mean age of 10.6 years. From data obtained from the Primary school Municipal Education Office as of 2009, more female pupils were enrolled in schools compared to males hence maybe a possible explanation as to why there were many females sampled compared to males. The males were 425 (48.1) and a mean age of 10.9 which is slightly higher than that of females. This mean age fall under the peak age of being at risk of being infected by *S. haematobium* that has been found in other studies such as the one done in Nigerian primary schools (Ejezie *et al.*,1981) whereby both the prevalence and intensity of infection were found to be highest in children aged 10± 14 years.

4.2 Prevelence and intensity of *S. haematobium* in the study population

The over all prevalence *S. haematobium* infection in Morogoro municipality was found to be 32.5% with over all intensity of 35.15% with the highest prevalence and intensity being recorded at Kilakala primary school (43.97% and 33.33%) respectively. Previous studies done in Morogoro region by the Regional Medical Officer revealed the prevalence to be 86% (2004). However the prevalence obtained in this study is lower but confirms that *S. haematobium* is still a disease that needs controlling. The difference in prevalence maybe attributed to different seasons when study was carried out since there is seasonal variation in the transmission of *S. haematobium* infection (Webb and Jordan,

1966). Also maybe due to the ongoing schistosomiasis control measures that are advocated by the Ministry of Health and Social Welfare, also to the mass administration of praziquantel to the primary school pupils.

In this study, 25.8% of the pupils that were sampled had low intensity of *S. haematobium* while 9.3% had high intensity, whereby females had higher intensity (51.92%) compared to males (48.08%). The variation in intensity of infection depends partially on the different levels of endemicity, the season when the study is conducted, the methods used and on the time when urine specimen are collected for analysis (Ndyomugyenyi, 1992).

Age of pupils also do play part when prevalence and intensity are being calculated and in this study the pupils between the age of 9 years to 11 years old had the highest prevalence of 51.22% and intensity of 53.73% compared to any other age group. The prevalence and intensity often observed in this age-group has been attributed to high human water contact and exposure to infection (Dalton and Pole, 1978). Also according to the same authors, the frequency of water contact was higher in the children among the age group 10-14 years than in any other age group. It is important to take notice of the age group 10-14 yrs is the most infected age group and hence the most contaminators of the water bodies since children in this age group showed the highest intensity of infection. Both in respect to population at risk and of the role played in transmission, this age group constitute the most significant age group.

Furthermore, it was observed that the percentage of pupils with heavy infection was considerably lower than those with light infection. An earlier report indicated that the distribution of schistosomiasis in endemic communities fits a negative binomial curve, with most infected persons harboring low worm burdens and only a small proportion having heavy infections (Mahmond, 2000). This may explain the trend we have observed. However, the aggregation of worm burden in a small proportion of infected individuals may have multiple explanations including genetic susceptibility (Secor *et al.,* 1996)

Classical sign of urinary schistosomiasis is macrohaematuria (Guyat *et al*, 1994; Carabin *et al*, 200). Haematuria correlated with intensity of the infection which is in accordance with other studies (Wilkins *et al*., 1979, Mott *et al*., 1983, Tanner *et al*., 1983). In this

study, it was found that there is a relationship between urinating blood in the past and *S. haematoium* infection. Even though the pupils that urinated blood and found to have infection were few (27.83%) yet they were 16.1 times more likely to be at risk of getting infected with the parasite than the pupils who did not urinate blood in the past.

Among the 287 pupils that were found to have *S. haematobium* infection, the prevalence of microhaematuria was 96.17% and that of macrohaematuria was 40.42%. There was an overlap of microhaematuria and macrohaematuria, explaining why their proportions exceed 100%. For both macrohaematuria and microhaematuria, the age group that had the highest proportion as 9 years to 11 years old. Pupils that had macrohaematuria were all positive for microhaematuria but for those with microhaematuria were not all positive for macrohaematuria. This was a single day result from filtration technique to determine haematuria. Thus has its down fall, whereby inadequacy of a single urine filtration to determine *S. haematobium* eggs. In a study done in Ifakara, Tanzania, observed that single day results were negative despite high intensity (>50 eggs/10ml urine) of infection on other days (Savigny et al., 1987). And for those pupils that haematuria was observed but no eggs detected, may be explained buy other infections such as Urinary Track Infections, menstrual bleeding in older female pupils and other medical conditions that were not examined in this study.

Macrohaematuria was found to be 40.42% which was lower that microhaematuria. In this study, observation was by naked eye looking at the various shades of urine where by there were three options, yellow, light red and dark red. No reagent strips were used but in another study carried out in Ilala district; used chemical reagent strips and reported a sensitivity of 84.3% (Ndyomugyenyi, 1992). That same study, used history of haematuria as a second sensitive indirect method to identify infected pupils (60.4%), visual observation was least sensitive (37.7%) but the most specific (91.7%). Therefore, school-based questionnaire methods reporting the occurrence of red urine can also be useful for targeting, or eliminating, areas for treatment where urinary schistosomiasis is likely endemic.

4.3 Risk factors for *S. haematobium*

In one study done in Ghana, the relationship between water contact habits of males and females to prevalence showed that among male pupils 41.2% engaged in swimming activities whereas only 29.3% of females were involved. Also 36.7% of the males and 32.6% of the females actually bathed in the River. Other activities in the water like washing of dishes and clothes attracted 22.0% and 38.0% of males and females respectively (Awotunde *et al.*, 2002)

Recreational water activities such swimming and playing in water has been observed to result into more frequent and intensive infection with potentially infective water in Egypt (Kloos *et al.*, 1982), in South Africa (Kvalsvig and Schuttle,1986) and in Tanzania (Lwihula, 1987). In this study, urinating habits were observed from pupils that went swimming in rivers and those whom at one point or another lacked a functioning toilet at home or school and hence urinated in rivers, streams or dams. Among the sampled pupils 48.9% admit to urinate in the water while swimming in rivers. Other studies have shown that transmission of urinary schistosomiasis occurs when the infected person urinates in the water bodies which serve as source of drinking or bathing, thereby introducing eggs which hatch into larva that infect the snail hosts (Gracio et al,.1992).

This study has looked at the risk factors that might have contributed to the transmission of *S. haematobium*. The pupils that bath in rivers, ponds, dams or streams were found to be 7 more at risk of being infected with *S. haematobium* compare to pupils that do not bath in these water bodies. For the pupils that did fish were 4 times more likely to be infected with the parasite than those students that did not fish. Also the pupils that liked to play in water were 3.7 times likely to be infected with *S. haematobium* than those that did not play in water. These noted risk factors play a role in exposing a pupil to be infected with the parasite and this is seen in other studies such as the one done by Engles and Savoli 2006, whereby they stated that *S. haematobium* infection is acquired through exposure to unsafe environmental water infested with schistosome larvae.

Our results showed that the males were generally more infected and with higher intensity than the females. This is presumably due to higher water contact activities by

male pupils particularly in the swamp-rice farming and fishing, where fathers engage every male in their household in the profession. In addition, other regular water contact activities such as swimming and bathing in cercariae infested streams and rivers are male dominated; besides, females in the area are usually restricted from swimming and bathing in the rivers on religious and socio-cultural grounds. This is similar to the observations made in other similar studies in Dar es salaam (Ndvomugyenyi and Minjas, 2001), Cote d'Ivoire (Yapi et al., 2005) and in south-western Nigeria (Okoli and Odaibo).

Majority of pupils in Morogoro municipality (personal observation) tends to swim in Morogoro River that runs across the municipality. Also these sampled schools send their students to fetch water from the river one to three times a week for gardening. Water contact directly determines the transmission of the disease since it increases the probability of schistosoma eggs reaching water. Also wearing of footwear to protect the legs could be a good protective measure against active penetration by the cercariae of schistosoma (Amano, 1990).

4.4 Praziquantel uptake among primary school children

Use of chemotherapy in the control of schistosomiasis was advocated long ago but a driving force came when the price of praziquantel was reduced. In addition, as part of the World Health Assembly 54.19 resolution, de-worming is firmly on the international health agenda and increasing access to ant-helminthics, particularly in school age children, is a key target promoted by the WHO, e.g. by 2010 at least 75% of school age children at risk of morbidity should have regular access to praziquantel (Savioli *et al.*, 2009). Over the current years praziquantel has been distributed to primary school children in Morogoro region, the last round being 2008.

This was taken into consideration in this survey and the results shows that 14.3% of students took praziquantel in the last annual distribution in Morogoro municipal, whereby more female pupils took the drug compared to male pupils. According to the Schistosomiasis Initiative Control Program, Morogoro region had the lowest coverage

among all regions that received praziquantel in 2008 general distribution. The students experience side effects such as fainting that created panic through out the community hence led to parents refusing their children from participating in the whole activity. Further personal investigation into the matter discovered that many students fainted because they were not fed properly prior to taking praziquantel, even though the municipal council did designate funds for food to each school for students to have been fed before taking the drug.

Those who took praziquantel in the last general distribution and yet had *S. haematobium* infection were few (3.96%) compared to those that did not take Praziquantel in the last general distribution (10.29%). The lack of difference maybe attributed to the fact that even the students that did agree to have taken the drug in the last general distribution might have lied or they truly did take the drug and managed to stay from contaminated waters.

Praziquantel should still be advocated and distributed, since the information about the accuracy of its distribution in the last round in the study area is sketchy. Furthermore, microhaematuria among the pupils whom had urinary schistsomiasis in this study was high 96.17%, thus distribution of the drug regardless of diagnosis is an effective way to cut down transmission and cure the disease.

4.5 Study limitations

This survey was done under supervision of the principal investigator and two research assistants. Limitations faced during the survey were as follows:

- Many female students were scared to give out urine samples in fear that they were being tested for pregnancy; hence they put water in the collection containers. Extra effort that involved teachers was needed to reassure the students of the intended purpose of the survey and to collect urine
- Due to delay of funds from the University, survey was started near the end of term of schools when students taking their exams, hence giving insufficient time to get equal sample of students from each school which led to have unequal

samples of students i.e.: one school providing more samples compared to the next school

- Cooperation from headmasters of schools was not equally satisfying. Faced with uncooperative response from headmasters and teachers in various schools that led to delay of data collection. Many teachers didn't want to be involved because they were scared of the last experience they had with praziquantel drugs and the negative impact it had in the community. In one school Mchikichini primary, many parents were reluctant to allow their children to participate in the survey
- Blood in female pupils urine sets as a limitation because it might be considered as macrohaematuria caused by *S. haematobium* but instead it might have been due to menstrual periods. Most female pupils were not willing to disclose this information thus making it harder in differentiating what was the cause of macrohaematuria.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study provides an important observation on the status of infection in this part of Tanzania and exemplifies the national efforts to advance active participation in schistosomiasis prevention and control activities at the sub-district levels. The study revealed that the prevalence of *S. haematobium* among primary school children in Morogoro municipality to be 32.5%. The students that received praziquantel in the study area were 14.3% and 25.8% had low intensity while 9.3% had high intensity of the parasite ova.

This study also revealed the risk factors that contributed into these pupils to be infected by the parasite. Factors such as playing in water, bathing in rivers, ponds, dams or streams, and fishing, were found to have a statistical significance in contributing to *S. haematobium* infection among the pupils. praziquantel uptake was very low in the study population which was explained by the severe negative side effects the pupils experienced in the last annual administration in 2008.

5.2 Recommendations

- Much effort is need in Morogoro municipal to restore the faith of community in mass administration of praziquantel. Administration of the drug it has proven in other areas where Urinary schistosomiasis is endemic, to be an effective control measure.
- The factors that do put these children at risk, needs to be further assessed and explored and more data needed so as to draw a reasonable conclusion that reflects the true population of the primary school children of Morogoro municipal and actual situation.
- Instructing pupils to correct personal habits which are conducive to infection and practice good personal hygiene can be an effective and safe substitute for repeated de-worming, reducing the opportunity for the emergence of drug-

resistance, which should prolong the time anti-helminthic drugs such as praziquantel may be used for treatment of urinary schistosomiasis

- In addition, complementary integrated control activities, such as environmental management measures, should be planned with other sectors such as agriculture and water resource development programs. It is also important to ensure that any development activity likely to favor the emergence or spread of schistosomiasis and other parasitic diseases is preceded by a proper health impact assessment and accompanied by preventive measures to limit their impact

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