Imperial College London

MSc Dissertation 2013

SCHISTOSOMIASIS PREVALENCE AND INTENSITY IN RELATION TO THE PROXIMITY OF LAKE MALAWI.

02/09/2013

CID 00576765

Word Count 10,491

Acknowledgements

I hereby declare the work contained in this dissertation is my own and written by myself.

I wish to thank my joint supervisors for their guidance with the method and analysis in person, through email and over skype with this project and SCI for their financial assistance.

I also wish to thank Dr Samuel Jemu the Schistosomiasis Control Manager in Malawi and his team who enabled this project to go ahead. Furthermore I wish to thank the head teachers and all the students who participated without hesitation.

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List of Abreviations

STH	Soil Transmitted Helminths
PZQ	Praziquantel
MDA	Mass Drug Administration
PCT	Preventive Chemotherapy
MoH	Ministry of Health
SCI	Schistosomiasis Control Initiative
WHA	World Health Assembly
SAC	School Age Children
WHO	World Health Organisation
DFID	UK Department of International Development
ICOSA	Integrated Control of Schistosomiasis in Sub Saharan Africa
S. *haematobium*	Schistosoma haematobium
S. *mansoni*	Schistosmia mansoni

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Abstract

Background. Previous studies have found a relationship between living in close proximity to a large water body such as Lake Victoria in Eastern Africa and the prevalence and intensity of *Schistosoma mansoni* infection but not *Schistosoma haematobium*. The lake shore districts of Lake Malawi have had four rounds of treatment for schistosomiasis with praziquantel (PZQ), the drug of choice for treating schistosomiasis, no survey had been done to determine if there was still a need for mass drug administration (MDA) what areas were at greatest risk and if there is a relationship between prevalence and proximity to the lake.

Method. A re-mapping survey was carried out by randomly selecting 15 schools from five lakeshore districts after stratifying for distance from the lake to allow analysis of distance and prevalence. 30 children from each school, 15 boys and 15 girls, aged 10-14 were randomly selected and tested for *s. haematobium* using the urine filtration technique and *s. mansoni* and Soil Transmitted Helminths's (STH) by Kato Katz. Questionnaires regarding frequency of water contacts were also answered by the children to establish if there was a link between frequency of water contacts and presence of infection. This data was used to derive district-level prevalence estimates, which can be used to inform on-going treatment programs in these areas. Binomial generalised linear mixed models (GLMM's) were used to model the probability of infection with either s. *haematobium* or s. *mansoni*, in relation to both school level characteristics, including proximity to the lake (water proximity stratum) as well as pupil characteristics such as age, sex, whether they had received PZQ in the last year and water contact.

Results. A total of 2440 children were sampled with mean age 11.86 years (SD=1.37) from 75 schools. In total, 9.0% were infected with *S. haematobium* and 5.2% with *S. mansoni*. Boys were found to have a significantly higher overall schistosomiasis prevalence than girls (odds ratio OR=0.36, 95% CI: 0.51-0.86) and younger children had a higher pooled prevalence than older children. Previous treatment and water contact had no significant effect on infection probability for either species. S.*mansoni* was found to have a significantly higher prevalence as you move away from the lake (OR=0.33,95%CI 0.11-0.97) and the final model supported a district*distance interaction. District, sex and age were all found to predict S. *haematobium* infection probability, with the districts Salima and Nkhata Bay; females and younger age groups having a lower prevalence. Overall the model suggested that the risk of schistosome infection was highest for males living away from the lake.

Hypothesis Proximity to Lake Malawi increases the prevalence of S. *mansoni* but not S. *haematobium* in the lakeshore districts of Malawi

1. Introduction

The Malawian Ministry of Health (MoH) has an on-going national scale treatment programme for schistosomiasis control. Nineteen districts are at varying stages of programme implementation. Five districts located on the shore of Lake Malawi are endemic for s. *mansoni* and s. *haematobium* and have received four rounds of annual treatment with Praziquantel and Albendazole since 2009(MoH report). According to WHO guidelines, after five to six rounds of treatment re-mapping should be carried out. The reasons for these re-mappings are two-fold: First to determine the required frequency of treatments and secondly to re-focus resources and ensure the programme is having an impact on disease. The districts of Zomba, Mangochi, Salima, Nkhotakota and Nkhata Bay have received four rounds of annual treatment for schistosomiasis and are at the cusp of requiring re-mapping surveys. It has been determined, by the MoH and their partners at the Schistosomiasis Control Initiative (SCI), that these five districts should be re-mapped a year earlier (i.e. in 2013 rather than 2014) due to poor quality of the original mapping data and the financial opportunity to do so.

1.2 Schistosomiasis

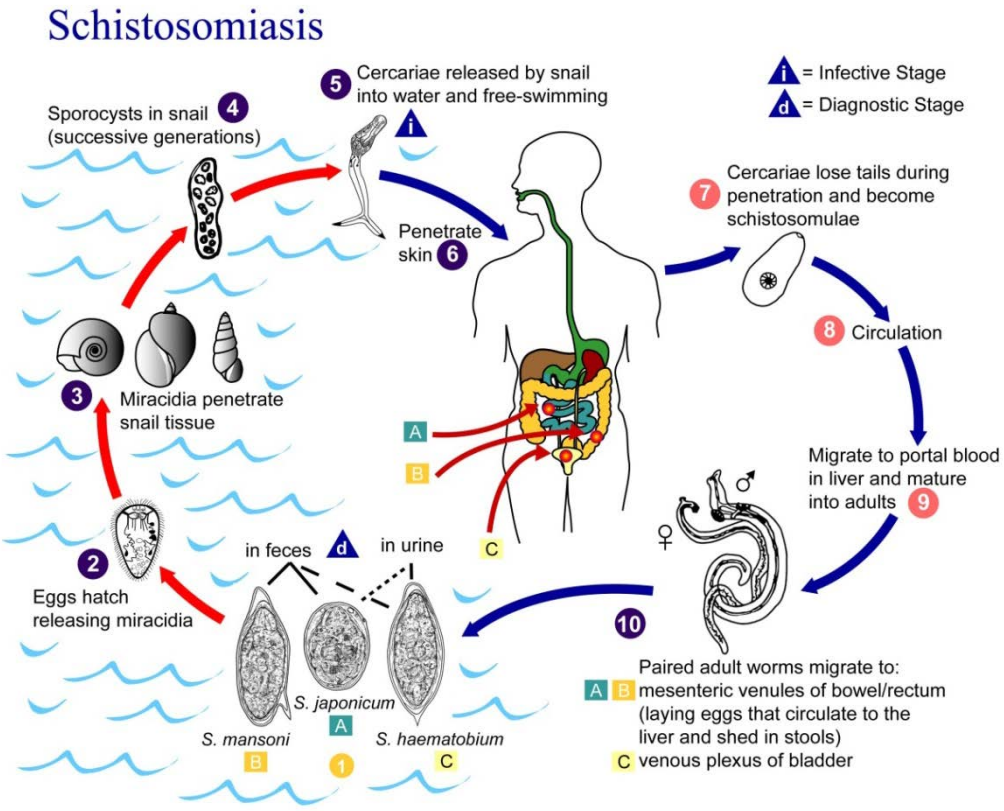
Schistosomiasis is a disease of poverty in which many factors come into play for its spread and survival (Simon Brooker et al., 2006; Hotez & Kamath, 2009; Muhumuza, Kitimbo, Oryema-Lalobo, & Nuwaha, 2009; Ntd, n.d.). Adult worms live in an infected person by attaching themselves to the blood vessels of either the intestine in the case of *s. mansoni* or the bladder when infected with s. *haematobium*. Male and female adult worms pair for life and can live together on average for five years. Mature, mated females produce eggs, which cause a variety of debilitating symptoms as they pass through the bodies tissues into the bladder or intestine. In the case of *s. haematobium* the infected person will experience lesions in the bladder wall and blood in the urine (Koukounari et al., 2007; Moestue et al., 2003; Sousa-Figueiredo et al., 2009) whereas, symptoms most commonly associated with *s. mansoni* include abdominal pain, diarrhoea and hepatic enlargement. Chronic symptoms such as ascites, bladder cancer and stunted growth appear after prolonged infection and often results in mortality(S Brooker et al., 2001; Dunne et al., 2006; Utzinger et al., 1998).

It is therefore imperative to identify infection and treat at an early stage. It is not only the person infected who is as risk from debilitating symptoms but also the entire community due to infectious eggs being released into the environment through human excreta.

Once released the eggs hatch on contact with fresh water releasing miracidia, motile stages which swim until they make contact with the intermediate snail host. They then penetrate the soft tissue of the snail. Once imbedded in the snail the parasite divides multiple times and within three weeks releases thousands of cercariae into the water for up to three months (Morgan et al., 2005; Southgate et al., 2000; Stensgaard, Jørgensen, Kabatereine, Rahbek, & Kristensen, 2006). If given the opportunity the cercariae penetrate the human's skin, and migrate through the host's blood circulatory system while developing into mature worms. Figure 1.1 depicts the life cycle of schistosomiasis.

There are six species of schistosomiasis known to infect man of which four are endemic in Africa. These are *s. mansoni*, *s. haematobium, s. guineensis* and *s. intercalatum*. Each species has specific intermediate host species and optimum transmission areas; however control methods are generally the same for all species.

Figure 1.1 The lifecycle of schistosomiasis



Source:http://www.dpd.cdc.gov/dpdx/images/ParasiteImages/SZ/schistosomiasis/Schistomes_LifeCycle.gif

1.3 Snail Hosts

The intermediate snail hosts have adapted to a wide range of environmental conditions. Their habitats can include almost all fresh water bodies from small ponds, large lakes, dams or rivers with moderate organic content such as plants, mud and decaying organic matter with densities that vary with the season and habitat.

Two species of snail, Bulinus and Biophalaria are the sole intermediate hosts for the three species of schistosomiasis prevalent in Africa. One method of controlling the spread of schistosomiasis is to control the local snail population. Chemical, Environmental and Biological control are three methods considered when attempting to interrupt transmission.

1.3.2 Chemical control

Molluscicide's have been widely used in the control of schistosomiasis and in many instances have proven to be very effective on small water bodies (Fenwick, 1987; Klump & Chu 1987 Gashaw, Erko, Teklehaymanot, & Habtesellasie, 2008; Pointier, DeJong, Tchuem Tchuenté, Kristensen, & Loker, 2005). However, this method unless carried out intensely and in conjunction with MDA is only a short term solution as rapid re-colonization can occur (Brown, 1994; Goll et al 1984; Duke & Moore, 1976).

1.3.3 Environmental Control

Altering the environmental habitats reduces the numbers or in some cases completely wipes out snail populations. Numerous ways of doing this have been proposed by Thomas & Tait (1984) and include altering light, water chemistry, water flow, sediment type, seasonal drying, aquatic and sub-aquatic plants, introducing other snail species and management of irrigation schemes (Uptham et al 1981, Brown, 1994). However, unless there is long term commitment from the local communities the rapid reintroduction of the species is inevitable (Laamrani et al. 2000).

1.3.4 Biological Control

Biological control methods range from introducing, pathogens and parasites, predators, competitors and genetic manipulation. Many of these ideas are still in their early stages and can prove to be very complex to implement. Due to overfishing of mollusciside eating fish, in certain regions of Lake Malawi there has been an increase in the number of schistosomiasis cases. There are now small community owned projects which have implemented fishing boundaries to try and re-establish the fish population with the hopes of reducing schistosomiasis (Eye of Malawi, 2013).

1.4 Risk factors for schistosomiasis and treatment guidelines

Any human that comes into contact with infected water can be a person at risk of contracting schistosomiasis. However, due their behavior, certain sections of the population appear to be at greater risk or more likely to spread the disease.

School age children (SAC), especially adolescents are generally the population targeted when considering treatment in the communities. They have been repeatedly shown to have the highest prevalence and intensities of infection due to their consistent water contact from bathing, fishing and swimming and age acquired immunity has not occurred. (Simon Brooker, Whawell, Kabatereine, Fenwick, & Anderson, 2004; Guyatt, Brooker, Kihamia, Hall, & Bundy, 2001; Pinot de Moira et al., 2007; Sow et al., 2011). Treating children can also prevent the development of high intensity infections, and therefore the development of severe morbidity (Dabo, Badawi, Bary, & Doumbo, 2011; Kouriba et al., 2005; Moussa

Sacko et al., 2011; Vester et al., 1997). Defecation by children, in areas close to water sources, also point to them being the population most likely to cause the continuation and spread of the disease. Therefore, it's wise to consider this group as a 'high risk' population. They are also regarded as most at risk as there are age related changes in susceptibility to schistosome infection as immunity develops with age (Fulford et al, 1998; Abebe, Gaarder, Petros, & Gundersen, 2001; Mitchell, Mutapi, Savill, & Woolhouse, 2012; Satti et al., 1996)

For these reasons, school-age children (SAC) generally have the highest burden of infection, and are thought to contribute a large amount to transmission. This group is the target of PCT, and is used for estimating community prevalence. The WHO have set prevalence cut offs for treatment guidelines. Table 1.1 shows the categories as defined by the WHO and the appropriate action the country programs should take to reduce schistosomiasis prevalence.

Table 1.1 Prevalence categories and action taken as advised by the World Health Organisation.

Category	Prevalence	Action for children	Action for community
High-risk	≥50%	Treat all school-age children once a year	Also treat adults considered to be at risk
Moderate-risk	≥10% but <50%	Treat all school-age children once every two years	Also treat adults considered to be at risk
Low-risk	<10%	Treat all school-age children twice during their primary schooling	Praziquantel should be available in dispensaries and clinics

In areas where there is moderate transmission i.e. SAC prevalence is found between 10-50%, focal groups who have greatest water contact are considered at-risk. These groups include fishermen, those working in irrigation areas, as well as pregnant or lactating women. For areas where the SAC have low prevalence i.e <10% it is advised to treat all children twice during school therefore 1/3 of SAC annually.

In regard to pre-school children, recent findings have shown that they should also be considered as an at risk group however much more work is needed on the PZQ delivery options (Garba et al., 2010; Stothard, Sousa-Figueiredo, Sousa-Figuereido, et al., 2011).

Malawi is endemic for both *s. haematobium* and *s. mansoni*. Annual mass treatment of enrolled school children with PZQ began in 2009, with the support of the Malawi Government, the WHO and World Vision. Treatment was initially carried out in 10 districts and scaled up to 18 districts by 2011, however, coverage was limited due to availability of PZQ and financial restrictions. A national mapping survey was carried out in 2002 sampling 30 schools across the country. Lower than expected prevalence was reported, which may be explained by the focal nature of the disease and the sparse nature of the survey, which may have missed endemic areas. Other limitations such as the use of thick smears instead of the more universally accepted Kato-Katz for diagnosis of *s. mansoni*, high technician workload and limited time also suggest this data may not be reliable (reference to report).

Additional support to the National schistosomiasis and STH control Programmes was provided with the UK Department for International Development (DFID) and the SCI under the Integrated Control of Schistosomiasis in Sub Saharan Africa (ICOSA) project in 2011. This initial five year support aims to assist scale-up to enable treatment of all school age children in Malawi, through the provision of PZQ and funds to support essential programme activities such as this, in addition to monitoring and evaluation. The five districts that have already received four rounds of MDA are due to be re-evaluated in order to continue with targeted treatment.

1.5 Preventive Chemotherapy and Praziquantel

Praziquantel (PZQ) is the drug of choice for schistosomiasis due its effectiveness on all species. PZQ effectively kills adult worms, (Karanja et al., 1998; Raso et al., 2004; M Sacko et al., 2009) however, juvenile schistosomes are not susceptible to PZQ, which can lead to re-occurrence (Ernould, Ba, & Sellin, 1999) and has brought forward the idea of increasing resistance to PZQ. Due to refugia, the selective non treatment of infected individuals, resistance thus far has not proven to be a problem. However in countries which have had long term regular widespread coverage it is being monitored, therefore research into other anti-schistosomal drugs is needed (Fenwick, Rollinson, & Southgate, 2006; Morgan et al., 2005; King, Muchiri, & Ouma, 2000). Species also react differently to treatment, with some evidence that PZQ is more effective against s. *haematobium* than *s. mansoni* (King et al., 2011).

Long term follow up studies regarding adverse effects show that PZQ has low toxicity, mild adverse symptoms, no malformation effects and no sequelae (Adam, Elwasila, & Homeida, 2005; Woelfle et al., 2011). A single dose of 40-60mg/kg has shown to have parasitological cure rate ranging between 70-100% (Midzi et al., 2008). Those not cured usually experience a significant reduction in infection intensity, but morbidity continues as the damage has already occurred.

Increased ease of PZQ administration has improved with the development of the simple dose pole used by trained teachers and community workers. This pole was developed to deliver a dose of 40-60mg/kg, in order to minimize under dosage and has been designed to identify five height intervals. This method of treatment has proven successful with numerous diseases where the treatment based on weight was not possible in remote settings (Stothard, Sousa-Figueiredo, Betson, et al., 2011). Subsequently, reaching the 75% coverage of all school-age children as postulated at the 2001 WHA is more attainable though coverage surveys often show lower coverage (Joseph et al., 2004; Ntd, n.d.)

Unlike other anti-helminthic drugs, PZQ still has to be purchased by the countries, or donated by control programs which in turn has either been donated or purchased from pharmaceutical companies and supplied through the WHO. There is a large gap however, in the number of PZQ tablets available and those needed to carry out complete annual coverage. Despite the cost of PZQ falling to $0.07, over the last 30 years the price in some cases is still above the per-capita health budgets of many endemic countries and represents the most significant proportion of the overall expenditures incurred by a schistosomiasis control program. (Narcis B Kabatereine et al., 2006; Stothard, Sousa-Figueiredo, Betson, et al., 2011).

1.6 Health Education, Sanitation and Water sources within Malawi

In a population of 14.9milion, 2.5 million Malawians still do not have access to clean water with a further 7million not having adequate sanitation, and only 2% with access to piped water inside their dwelling (Framework & Overview, 2007). Transmission of schistosomiasis will always continue as long as fresh water is contaminated with an infected human's excreta. Improvement in sanitation and health education in areas of high and low transmission leads to a decrease in prevalence of schistosomiasis and is one of the proposed interventions when aiming to reduce morbidity due to schistosomiasis (Knopp et al., 2010; Lansdown et al., 2002; Müller et al., 2011) (Wang et al 2009; Knopp et al 2011). Improving these variables will not only enhance the control of schistosomiasis but will also benefit the community as a whole, as thousands children under five years of age die a year as a result of water borne diseases spread by fecal contamination (Halvorson, Williams, Ba, & Dunkel, 2011; Report, 2010; Sow et al., 2011; Woelfle et al., 2011).

There are three categories of water sources in Malawi, namely underground water, surface water (Lake Malawi) and rivers. Underground sources are boreholes, protected shallows, open wells (unprotected) and springs. The Water Board pumps water from the lake as raw water treated with chlorine and then distributed to the communities especially in semi-urban zones of the district by household connectivity. Access to safe water varies greatly across and within districts.

Malawi has a major problem with water availability and therefore water development projects are continually underway. However, with improved water sources such as dams and reservoirs there is the risk of increasing the transmission of schistosomiasis as seen with the development of the dam in the Senegal River basin (de Clercq et al., 2000; Ernould et al., 1999; Sow, de Vlas, Mbaye, Polman, & Gryseels, 2003). If appropriate steps are not taken to ensure that the available water stays uncontaminated by increasing numbers of latrine facilities, health education and better personal hygiene behavior, a reduction in schistosomiasis transmission will not occur and the advances in reducing morbidity through treatment will be reversed.

1.7 The relationship between schistosomiasis endemicity and proximity to large water bodies

Schistosomiasis is a focal, waterborne disease. It is therefore natural to hypothesize that people who live in close proximity to a large water body such as Lake Malawi will be at greater risk of contracting the disease. This has been reported in many studies throughout the Great Lake regions of Eastern Africa as well as a few studies within Malawi. In contrast to Lake Victoria and Lake Albert in Uganda, Kenya and Tanzania, which are highly endemic for *s. mansoni*, studies have shown Lake Malawi to be more endemic for *s. haematobium* than s*. mansoni* infection (Bowie, Purcell, Shaba, Makaula, & Perez, 2004; Cetron et al., 1996; Madsen et al., 2011; Makaula et al., 2012).

1.7.2 S. *haematobium* and Lake Malawi.

A recent study carried out in the years before PCT in Mangochi, a district situated at the southern tip of the lake has shown that those with regular contact and closer proximity to the lake have an increased *s.*

haematobium prevalence The prevalence's reported ranged from 10.2-26% for inland communities to high prevalence's of 21-72.7% in the lake shore schools (Madsen et al., 2011; Friis et al., 1997; Madsen et al., 2011; Thiong'o & Ouma, 2001).

Furthermore studies that interviewed expatriates in Malawi involved the recording of participants water contact and demonstrated, for the first time, that recreational freshwater exposure in Lake Malawi is an important source of transmission (Cetron et al., 1996).

1.7.3 S. *mansoni* and Lake Malawi

With regards to s. *mansoni*, which has been documented repeatedly by studies in Uganda on the Sesse Islands in Lake Victoria and around the shores of Lake Albert as well as those in rural area as close to the southeast of Lake Langano, Ethiopia, have all demonstrated that dwellings in close proximity to the lakes show a higher prevalence of s.*mansoni* within a five kilometer boundary (N B Kabatereine et al., 2003, 2004; Kazibwe et al., 2010; Legesse & Erko, n.d.; Standley, Adriko, Besigye, Kabatereine, & Stothard, 2011). In the case of Malawi however, Madsen reported the opposite finding with higher prevalence being found in the inland areas (Madsen et al., 2011).

Previous mapping that has been carried out in other parts of Malawi have found considerable variation in the distribution of s.*mansoni* and s.*haematobium* in other districts as well as areas of co-infection (Jemu, Msyamboza, Mazinga, Chiwaula, & Mderu, 2012).

Presently there is no documented evidence to suggest that Lake Malawi influences the presence of schistosmaisis. Malawi is known for its abundance of water and rivers throughout the country therefore it is possible that individual rivers and smaller water bodies play a larger role than the lake itself.

2. Aim

The primary aim of re-mapping is to categorise the five considered lakeshore districts in Malawi into WHO prevalence categories, such the locations needing treatment with PZQ, and at what frequency. More broadly, the re-mapping will enhance knowledge of the spatial distribution of schistosomiasis and soil-transmitted helminths (STH) in these five districts of Malawi. The reassessment surveys will involve the random sampling and testing of school-age children for the presence of s*. mansoni* and *s. haematobium* infection in pre-defined strata based on the distance from Lake Malawi.
The secondary aim is to analyse the relationship between proximity to the lake and schistosomiasis prevalence and intensity, separately for *s. mansoni* and for *s. haematobium*.

In light of the literature available as well as the lack of research carried out on s.*mansoni* and s.*haematobium* around the lakes shores of Lake Malawi, I have chosen a stratified sampling design for re-mapping schistosomiasis with three strata designated on the basis of proximity to the lakeshore: <5km, 5-15km and >15km from the lake. Due to the focal nature of the disease and the impact of water on transmission it is important to know the variability within a district to plan for future treatment. A

stratified design will allow me to (i) test the relationship between lake proximity and prevalence and (ii) increase precision of a district-level prevalence.

3. Method

This re-mapping survey was carried out in 15 schools across five lakeshore districts in Malawi that have received four rounds of PZQ treatment. Figure 3.1 highlights the districts where the reassessment was carried out.

3.2.1 Nkhata Bay

Nkhata Bay District is one of the six districts in the Northern Region of Malawi averaging 485m above sea level covering an area of 4,071 sq. km. The district is broken up into 5 distinct areas. The Viphya Plateau located to the west of the district lies at an altitude of 1,900m above sea level; Lake shore plain lies in the Rift Valley Floor; Rift Valley Scarp extends from the Central of the district extending to the northern part; The hill zone occurs in the northern part and is characterized by moderate to steep slopes and the marshes and wetlands predominantly occur along Limphasa and Lweya rivers which are located in the Central and South East of the district

The total population of Nkhata Bay is 303,659 with 62,348 SAC according to the 2006 Census. Of this population 75,368 are enrolled in education; 38,564 boys and 36,804 girls according to a 2008 survey(Households, n.d.)

3.2.2 Nkhotakota

Nkhotakota district is one of the nine districts in the Central region of Malawi located on the west coast of Lake Malawi covering an area of 7500 sq.km with the lake occupying 43% of the total area. The district is located within the Central African Rift Valley. The Central African Plateau is separated from the Rift Valley System by the escarpments in the hilly areas. The land surface is generally flat, with the coastline primarily consisting of sandy beaches punctuated by marshes with a slight slope towards the lake. Elevation ranges from 493m to 1638m above sea level.

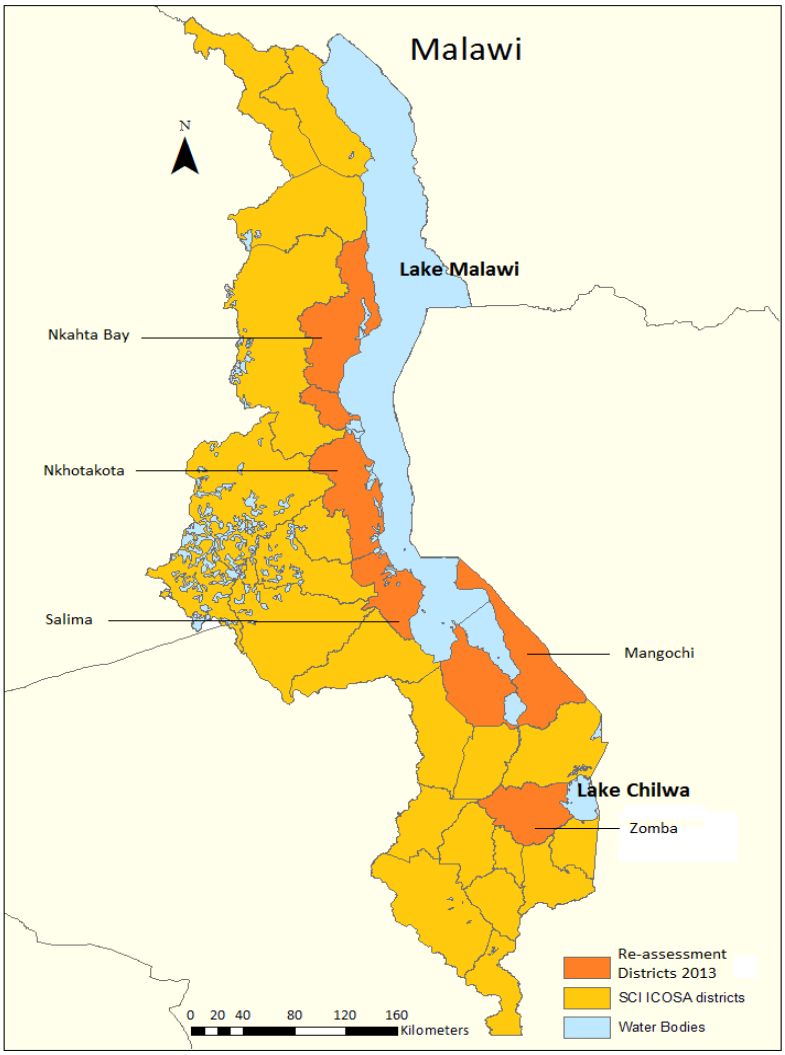
Nkhotakota's population according to the 2006 census is 229,460 of which 62,900 are 5-14 years. The total enrolment in public primary schools has increased over the years, with 90,994 eligible children enrolled in school of which 47,121 are boys and 43,853 are girls (District & Economic, 2010).

3.2.3 Salima

Salima district is located in the Central Region of Malawi, with a total land area of 2,196 sq.km. The two main landforms are the rift valley floor and the scattered hilly upland areas lying between 200 and 1000 meters above sea level.

The district has a population of about 309,300 based on 2.5% annual growth projections from the 1998 Census. Total primary enrolment is roughly 78,000 with over 40,500 girls and 37,900 boys. However, it is estimated that 42% of SAC are out of school ("Salima District Socio Economic Profile," 2006)

Figure 3.1. Map of Malawi and districts highlighted that will be reassessed



3.2.4 Mangochi

Mangochi District is situated in the Southern Region of Malawi at the Southern end of Lake Malawi with a total land area of 6,273 sq.km. Mangochi lies in the rift valley; the land is punctuated by highlands and hills. Mangochi's topography can be divided into two distinct categories; the rift valley/coastal plains and the hilly-forested areas, which rise above the plains.

Total population of the district was estimated at 755,039 in 2006 with 151,945 SAC; 76,296 males and 75,649 females. School enrolment increased to 149,675 in 2006. Representing 71 % of the primary school going age population. However the enrolment for girls is low at 50% ("MANGOCHI DISTRICT ASSEMBLY DISTRICT SOCIO-ECONOMIC PROFILE," n.d.).

3.2.5 Zomba

Zomba District is one of 12 districts in the Southern Region covering a land area totalling 2,580 sq.km. The topography of Zomba district varies from mountainous and hilly regions in the Western part of the district to the broad, flat plains of Lake Chilwa in the East. District elevation varies from 2,085 metres above sea level on Zomba Plateau to 627 metres at Lake Chilwa.

The total population of Zomba is 592,000 based on the projection from the 1998 census. Of this population 153,368 are of school age 76,998 females and 76,370 males with a school enrolment number of 147,417 (96%) of the eligible population ("Zomba District Socio-Economic Profile," 2007).

3.3 School Selection

The mapping survey involves a stratified two-stage cluster design, with stratification by proximity to the lake. Three strata were used in each district (<5km/stratum 1, 5-15km/stratum 2 and >15km/stratum 3 from Lake Malawi), based on previous findings on *s. mansoni* in Uganda, which show 5km is roughly the scale at which lake proximity influences prevalence (Odiere et al., 2012; Odongo-Aginya et al., 2002). These strata will therefore allow the results of this survey to be more directly comparable to previous studies on the influence of lake proximity.

In each district, 15 schools were selected (five in each stratum). The sample size was calculated to provide reasonable precision (margin of error) on district-level prevalence estimates. The sample size calculations indicated that 15 schools would allow us to estimate district-level prevalence with an expected margin of error of 10 percentage points. In other words, we expect to be able to say with 95% confidence that our district-level prevalence estimate is within +/-10 percentage points of the true value. These calculations are based on a district-level estimate of *rho* for schistosomiasis of 0.15 (based on recent ICOSA mapping exercises in Malawi and Zambia), a conservative estimate of prevalence at 30% and sampling 30 children per school. This calculation ignores stratification, which will increase precision. Neither GPS coordinates nor measurements of lake proximity were available for individual schools therefore the school selection was carried out in the following way.

A comprehensive database of the schools in each district with head teacher phone numbers was acquired from the Ministry of Education. Each head teacher was then contacted and asked to report approximately how far the school is from Lake Malawi. In the cases where we could not reach a head teacher the District Education Officer was asked to provide this information. A database was then created and sorted into distance strata. Schools were then randomly selected using the RAND function in excel. Five schools from each strata were chosen with two extras as standbys. Table 3.1 contains the schools chosen in each district and stratum.

In Nkhata Bay two schools in the original selection were dropped as they were not accessible with transport. Two standby schools were then used. This was also the case for one school in Nkhotakota, two in Mangochi, two in Zomba and one in Salima as the children on arrival within the school were found to be <10 years of age.

Table 3.1 Schools selected in each district for each stratum after initial consultation with head teachers.

District	Stratum 1 Schools <5km from lake	Stratum 2 Schools 5-15km from lake	Stratum 3 Schools >15km from lake
Nkhata Bay	Munkhokwe	Kamundi	Nkhokoma
	Mdyaka	Chiomba JP	Susa
	Thoto	Chinguluwe	Chendasi
	Sanje	Masefu	Mzenga
	Maula	Chilundwe	Kaulasisi
Nkhotakota	Matiki	Mndira	Katope
	Chiphole	Chimgonda	Bowa
	Msamala	Chanthomba	Nambale
	Nyavuu	Kanyenje	Namsongole
	Dwambadzi	Tipate	Mpongozipita
Salima	Thugulu	Chimweta Primary	Kavunguti
	Domira Bay	Chionjeza FP	Naluva
	Chigolo	Mauni	Nankhata
	Naliwomba	Chiluwa 1	Mtemeyiti
	Thokozani	Chigombe	Msaza
Mangochi	Mchoka	St Paul Primary	Majuni
	Ulande	Funwe	Mdinde
	St Augustine 3	Mwambazi Junior	Chowe
	Mikombe	Taliya	Kadyangunde
	Mpondas	Chimesya	Msusa
Zomba	Satema LEA	Chalomwe LEA	Mapalo
	Mafuwa	Nsondole FP	Guta FP
	Mitole	Namakwena	Luwezi
	Kachulu	Nakhombe	Kalira
	Chinkhwangwa	Mtondo	Mchenga

3.4 Pupil Selection

15 girls and 15 boys between the ages of 10-14 years were systematically sampled from each school. Girls and boys were assembled in two separate lines. The number of children in the line was divided by 15 to provide a starting point, *n*. Every *nth* child was selected from the line to finally obtain 17 boys and 17 girls, to allow for loss of or inability to provide a sample.

3.5 Recruitment

All children who were selected and provided samples as well as a consent form were included in the sample. As this was voluntary participation they were allowed to withdraw from the study at any time, written and oral consent forms were signed by the head teacher in a language they understood. Knowledge of the study was communicated to the schools via the District Education Officer before arrival at the school and again on the day of the testing.

Participants were instructed to deposit one faecal and one urine sample by container with individual identification numbers (IDs) to the field team. They were also asked a few questions regarding water contact with a yes/no and how frequent answer:

- Do you swim in the lake/river?
- Do you collect water from lake/river?

- Do you use the lake/river for; bathing, playing , washing clothes, fishing?
- Did you receive tablets last year?

These questions were explained to the children and referred to open water contact and did not include water collected from a bore hole or well. Treatment questions were asked regarding praziquantel specifically. Examples of the forms used can be found in appendix c.

3.6 Data Collection and Parasitology

3.6.1 Urine Testing

All urine samples were initially tested for micro-haematuria (blood in urine), scored with an increasing level as trace, 1+, 2+ 3+, using Hemastix dipsticks. All those appearing positive were prepared for urine filtration. Where enough urine was provided (>10ml) two slides were prepared for each sample, in the cases where limited urine was available the volume used to prepare the slides were recorded and egg counts were measured, so that the intensity (eggs per 10ml) could later be calculated. The slides were prepared and read within an hour.

3.6.2 Stool Samples

Stool samples were collected in plastic containers and two slides were prepared using the Kato Katz technique for microscopic analysis (Rabello, Pontes, & Dias-Neto, 2002). The number of eggs on each slide were recorded on individual paper forms and later entered onto an electronic database. The first slides were read at the school for STH's to avoid degradation of hookworm eggs and s. *mansoni*, while the second slides were read for s. *mansoni* 24hrs later.

When a positive result was found for either infection the children were treated with praziquantel or albendazole according to WHO guidelines.

3.6.3 School information and WASH forms

Data on the location of each school (longitude and latitude) was obtained using a hand held GPS device at arrival and again at departure. Treatment history of the school as well as the water and sanitation facilities at the schools were collected with the assistance of the head teacher on standardised forms (appendix f and g).

3.7 Statistical Analysis

Completed forms were returned to the MoH laboratories and organised by type of form. Data clerks were trained in reading the data recorded in the forms and how to enter this data using an Excel database designed specifically for this survey. In teams of two, all the data was double entered and checked by the managing data officer. Discrepancies were dealt with immediately and documented.

Binary prevalence and intensity variables were created for each child based on the presence (1) or absence (0) of eggs. Infection intensity was coded as 1 for low intensity <50 eggs/10 ml urine and 2 for

high intensity >50 eggs/10 ml urine, and <100epg for light intensity and >100epg for high intensity of s. *mansoni*. Water contact was scored on a categorical scale 4=everyday, 3= 4-6times a week, 2= 1-3 times a week, 1= sometimes, 0= never and a total contact score was calculated.

All analysis were performed using SAS statistical software (v. 9.3; SAS Institute Inc., Cary, NC, USA) for the 75 schools and 2240 children.

3.7.1 Calculation of district-level prevalence

In a study such as this where children are sampled from within a school, district or strata the observations are not independent due to the clustered survey design. Failure to take account of this clustering can lead to artificially narrow confidence intervals, and falsely inflated *p*-values. Thus in analysis of district level prevalence, the PROC SURVEYFREQ function was used in SAS v9, which accounts for clustering when calculating prevalence estimates and *p*-values. Sampling weights were also assigned based on the proportion of primary schools in the original sampling frame that were in each stratum. These were calculated as the total number of schools in each stratum *N* divided by the number of schools selected *n=5* in that stratum.

95% confidence intervals (CI_{95}) were estimated using the exact method.

3.7.2 Modelling factors that predict infection probability

The GLIMMIX procedure in SAS was used to run binomial generalised linear mixed models (GLMMs) with a logit link, to model the probability of infection with either s. *haematobium* or s. *mansoni*. All models included school as a random factor (to account for the clustered nature of the dataset) and district was included as a 5-level fixed effect. Several school-level characteristics were tested, including proximity to the lake (water proximity stratum) as well as pupil characteristics such as age, sex and whether they had received PZQ in the last year based on the head teachers response (see results Tables 4.9, 4.10 and 4.11 for a full list of terms). Modelling followed a backwards stepwise elimination procedure. After exploring each factor individually, a global model including all terms of interest was created, before simplifying by sequential removal of non-significant terms ($p<0.05$) to arrive at the minimum adequate model. Odd ratios and confidence intervals were extracted for district, sex, individual PZQ treatment, and water proximity stratum. Several interactions were also included in the models. These were distance*district, water contact*treatment and treatment*distance. This was to test whether the effect of water proximity varied across districts, and also whether the effect of treatment was dependant on the frequency of water contact or water proximity.

4. Results

4.2 Prevalence of schistosomiasis across districts

A total of 2240 children from 75 schools from grades 3-6 were selected, mean ages 11.86(SD=1.37, range 8-17years). After initial conversations with head teachers, 15 schools were randomly selected, five from each strata categorised into distance from lake 0-5km, 6-15km and <15km. After the survey, schools were mapped using ArcGIS to determine their precise location and verify initial stratification. After reclassification of schools into new strata's according to GPS coordinates the number of schools per strata in each district altered somewhat. The number of schools sampled in the near to lake strata in Zomba was reduced to two whereas the number in Nkhotakota increased to nine. Despite the skewed results from GPS coordinates overall the distribution of schools per strata was relatively equal with strata two having three less schools than the others. Table 4.1 displays the number of children sampled from each new strata calculated by distance to lake from GPS coordinates per district.

Table 4.1. Number of children sampled in each stratum after distance verification in ArcGIS.

Strata	Nkhata Bay	Nkhotakota	Salima	Mangochi	Zomba	Total
<5km	180	270	150	119	60	779
6-15km	120	90	120	235	117	682
>15km	150	90	180	90	269	779
Total	450	450	450	444	446	2240

4.3 Geographical Parasitological outcomes

4.3.1 School Prevalence

Distribution of both s. *haematobium* and s. *mansoni* varied by district and stratum. Nkhata Bay had the lowest number of schools infected with 7 schools having no infection compared to Zomba where only one school was absent of any infection.

Tables 4.2, 4.3, 4.4, 4.5 and 4.6 display the results by school and includes the number of children sampled, mean ages and prevalence of each species within the school. Figure 4.1 displays the location of each of the schools and their associated pooled schistosomiasis prevalence as well as district-level prevalence.

Table 4.2 Nkhata Bay School prevalence by stratum

District	Strata	School	Distance (km)	Number Examined	Mean Age	Std Dev	S.haematobium Prevalence (95% CI)	S.mansoni Prevalence (95% CI)
Nkhata Bay	1	Chiomba JP	3.23	30	10.33	0.76	10(0-21.39)	10(0-21.39)
		Maula	1.22	30	10.87	1.01	26.67(9.87-43.46)	
		Mdyaka	1.19	30	11.3	1.32		
		Munkhokwe	3.09	30	11.53	1.04		
		Sanje	0	30	11.4	0.89		
		Thoto	0.19	30	12.2	1.4		
	2	Chilundwe	14.7	30	11.1	1.12		3.33 (0-10.15)
		Chinguluwe	8.12	30	11.73	1.36		
		Kamundi	13.88	30	10.9	1.16	3.33(0-10.15)	3.33 (0-10.15)
		Mzenga	13.04	30	11.1	0.88		3.33 (0-10.15)
	3	Chendasi	25.67	30	10.87	0.9		3.33 (0-10.15)
		Kaulasisi	20.97	30	11	1.1	3.33(0-10.15)	
		Masefu	23.13	30	11.77	1.5	3.33(0-10.15)	3.33 (0-10.15)
		Nkhokoma	22.65	30	11.24	1.21		
		Susa	25.34	30	11	1.02		

Table 4.3 Nkhotatkota School prevalence by stratum

District	Strata	School	Distance (km)	Number Examined	Mean Age	Std Dev	S.haematobium Prevalence (95% CI)	S.mansoni Prevalence (95% CI)
Nkhotakota	1	Chanthomba	0.45	30	11.97	1.03	10(0-21.39)	
		Chimgonda	4.17	30	11.43	1.17	13.33(0.42-26.24)	
		Chiphole	2.14	30	11.33	1.12		
		Dwambadzi	2.14	30	11.10	1.18	20(4.81-35.19)	6.67(0-16.14)
		Kanyenje	3.82	30	12.67	1.54	16.67(2.51-30.82)	6.67(0-16.14)
		Matiki	3.34	30	11.30	0.99	13.33(0.42-26.24)	13.33(0.42-26.24)
		Msamala	1.94	30	11.17	1.39	6.67(0-16.14)	
		Nyavuu	4.9	30	10.87	1.11	36.67(18.36-54.97)	
		Tipate	2.59	30	11.67	1.3	40(21.39-58.61)	
	2	Bowa	8.95	30	11.43	1.17	13.33(0.42-26.24)	
		Mndira	6.38	30	10.77	1.04		
		Mpongozipita	6.79	30	11.33	1.18	13.33(0.42-26.24)	3.33 (0-10.15)
	3	Katope	18.61	30	11.33	1.09	30(12.60-47.40)	
		Nambale	16.47	30	12.37	1.07		
		Namsongole	18.29	30	11.37	1.19	10(0-21.39)	

Table 4.4 Salima School prevalence by stratum

District	Strata	School	Distance (km)	Number Examined	Mean Age	Std Dev	S.haematobium Prevalence (95% CI)	S.mansoni Prevalence (95% CI)
Salima	1	Chigolo	0	30	12.93	1.23		
		Domira Bay	2.85	30	11.30	1.24	6.67(0-16.14)	3.33 (0-10.15)
		Mtemeyiti		30	11.93	1.46	6.67(0-16.14)	53.33(34.39-72.28)
		Thokozani	1.09	30	11.67	1.12	6.67(0-16.14)	
		Thugulu	2.89	30	10.60	0.89	10(0-21.39)	
	2	Chiluwa 1	7.18	30	12.77	1.14	3.33(0-10.15)	
		Chionjeza FP	7.92	30	12.77	1.14	16.67(2.51-30.82)	3.33 (0-10.15)
		Mauni	6.65	30	11.90	1.06		
		Naliwomba	6.19	30	11.93	1.08	3.33(0-10.15)	
	3	Chigombe	17.47	30	11.70	1.21	3.33(0-10.15)	13.33(0.42-26.24)
		Chimweta	15.93	30	10.60	1.10		
		Kavunguti	26.44	30	12.14	1.36		63.33(45.03-81.64)
		Msaza	22.17	30	12.00	1.34		3.33 (0-10.15)
		Naluva	23.61	30	10.73	0.87	13.33(0.42-26.24)	6.67(0-16.14)
		Nankhata	19.31	30	12.47	1.46	16.67(2.51-30.82)	

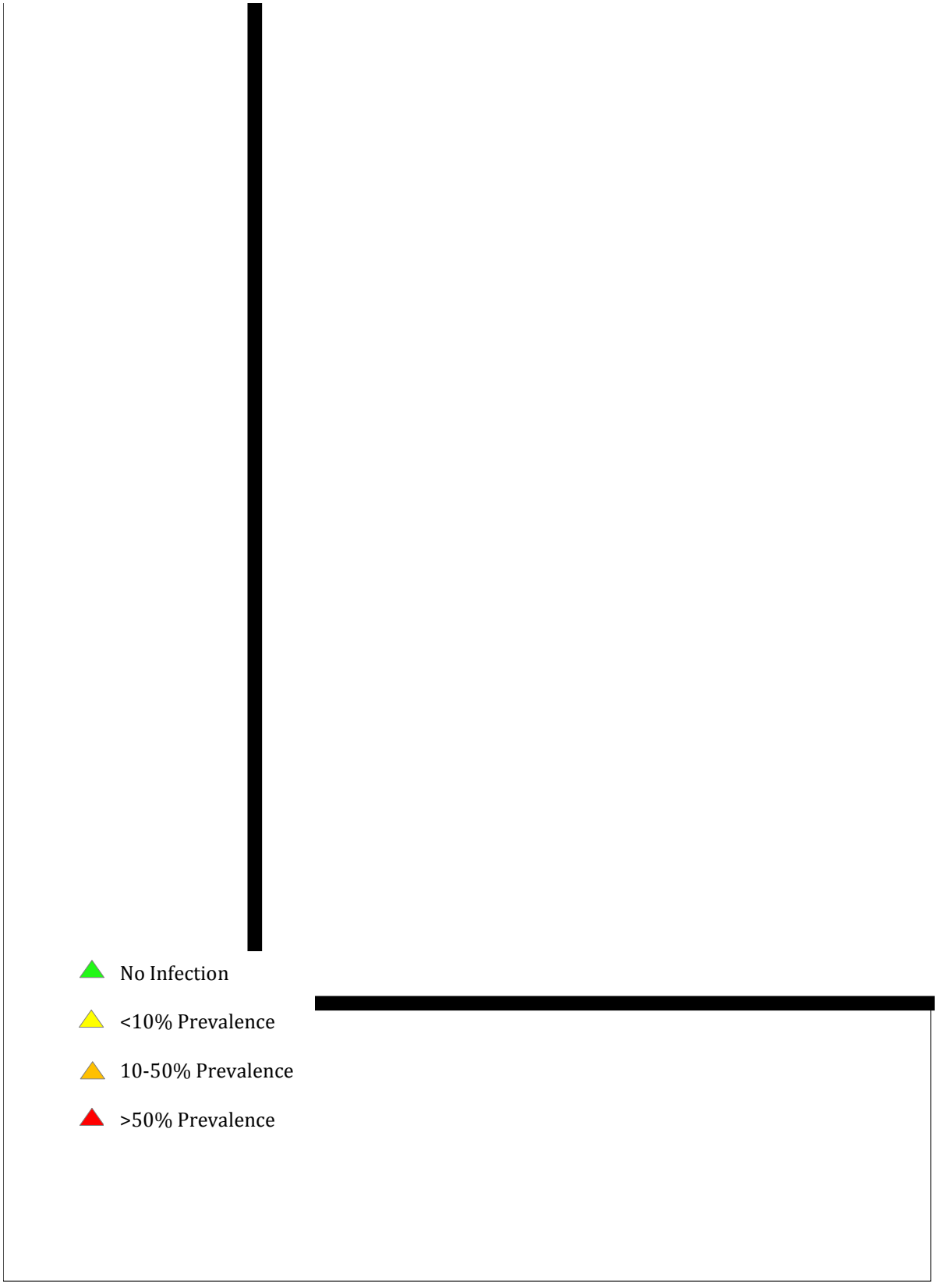
Table 4.5 Mangochi School prevalence by stratum

District	Strata	School	Distance (km)	Number Examined	Mean Age	Std Dev	S.haematobium Prevalence (95% CI)	S.mansoni Prevalence (95% CI)
Mangochi	1	Mchoka	2.11	30	12.43	1.14	13.33(0.42-26.24)	
		Mikombe	1.54	29	13.52	0.95		
		Mpondas	4.99	30	11.67	1.06	6.67(0-16.14)	
		Ulande	0.45	30	12.77	1.22	6.67(0-16.14)	
	2	Chimesya	10.59	29	12.59	1.21	17.24(2.62-31.86)	
		Chowe	11.63	30	12.70	1.34	3.33(0-10.15)	
		Funwe	10.82	30	12.53	1.11	13.33(0.42-26.24)	6.67(0-16.14)
		Kadyangunde	14.59	30	12.63	1.07	16.67(2.51-30.82)	
		Mwambazi Junior	8.69	30	10.93	0.98	26.67(9.87-43.46)	3.33 (0-10.15)
		St Augustine 3	5.55	30	12.00	1.14		
		St Paul Primary	8.59	26	12.73	1.95	3.84(0-11.77)	
		Taliya	5.34	30	13.17	1.18	13.33(0.42-26.24)	3.33 (0-10.15)
	3	Majuni	16.85	30	12.57	1.19		
		Mdinde	23.6	30	12.57	1.48	10(0-21.39)	40(21.39-58.61)
		Msusa	38.61	30	13.77	1.22	66.67(48.77-84.57)	10(0-21.39)

Table 4.6 Zomba School prevalence by stratum

District	Strata	School	Distance (km)	Number Examined	Mean Age	Std Dev	S.haematobium Prevalence (95% CI)	S.mansoni Prevalence (95% CI)
Zomba	1	Kachulu	1.01	30	12.73	0.87	16.67(2.51-30.82)	
		Mitole	4.61	30	12.13	0.90	6.67(0-16.14)	3.33 (0-10.15)
	2	Chinkhwangwa	6.27	30	11.67	0.99	13.33(0.42-26.24)	
		Mafuwa	8.39	30	12.03	1.59	3.33(0-10.15)	6.67(0-16.14)
		Nakhombe	8.75	27	11.67	0.73	11.11(0-23.78)	18.52(2.86-34.18)
		Nsondole FP	10.56	30	12.27	1.01	13.33(0.42-26.24)	3.33 (0-10.15)
	3	Chalomwe LEA	24.84	30	12.27	1.23	6.67(0-16.14)	6.67(0-16.14)
		Guta FP	47.94	30	12.43	1.04	10(0-21.39)	53.33(34.39-72.28)
		Kalira	48.65	29	12.48	1.02	13.79(0.44-27.14)	10.34480-22.13)
		Luwezi	44.64	30	12.50	1.04	10(0-21.39)	3.33 (0-10.15)
		Mapalo	16.93	30	12.97	0.96	13.33(0.42-26.24)	10(0-21.39)
		Mchenga	34	30	12.70	1.26	10(0-21.39)	
		Mtondo	22.84	30	11.80	1.19	6.67(0-16.14)	3.33 (0-10.15)
		Namakwena	26.28	30	11.79	1.40	6.67(0-16.14)	6.67(0-16.14)
		Satema LEA	28.23	30	11.47	1.31	3.33(0-10.15)	

Figure 4.1 The five re-mapped districts in Malawi with location and prevalence categories for sampled schools. Districts coloured coded by prevalence; yellow = Low, orange=Moderate



4.3.2 District Prevalence

Overall there was a higher prevalence of s.*haematobium* infection than s*. mansoni*, (9% vs 5.22% across all five districts). Zomba had the highest pooled level of any infection with 21.36% (95% CI 8.2-34.54) with Mangochi having the highest prevalence of s.*haematobium* 14.36% (95% CI 0.19-28.54) and Zomba reaching a moderate level of prevalence for s.*mansoni* 12.48% (95% CI 0-26.38). Nkhata Bay had the lowest prevalence for both s.*haematobium* and s.*mansoni*, 2.96%(95% CI 0-7.56) and 1.51%(95% CI 0.13-2.89) respectively. Table 4.7 summarizes the survey results for species in each strata with the 95%CI.

Table 4.7 Infection prevalence by district for individual species and pooled prevalaence as well as risk categories as defined by WHO guidelines.

District	Any Infection			S.*haematobium*		S.*mansoni*	
	+ve	Prevalence %(95% CI)	Risk Category	+ve	Prevalence %(95% CI)	+ve	Prevalence %(95% CI)
Nkhata Bay	22	4.85(0-9.77)	Low	14	3.33(0-7.99)	8	1.51(0.13-2.89)
Nkhotakota	79	16.71(9.88-23.54)	Moderate	73	15.14(8.04-22.23)	9	2.36(0-5.06)
Salima	49	11.44(3.14-19.75)	Moderate	26	6.07(2.46-9.69)	25	5.87(0-13.66)
Mangochi	85	20.46(4.78-36.13)	Moderate	72	16.65(1.85-31.46)	19	5.65(0-14.41)
Zomba	78	22.46(9.48-3544)	Moderate	44	10.7(9.14-12.26)	37	12.48(0-26.38)

4.3.3 Stratum Prevalence

Contrary to what was expected when prevalence was measured for strata's using the SURVEYFREQ procedure to determine stratum prevalence's there were obvious trends. However stratum three, classified as >15km had the highest prevalence for both s. *haematobium* and s. *mansoni* 12.85%(95% CI 3.74-21.96) and 11%(95% CI 1.76-20.24) respectively. s. *haematobium* in the near and middle strata's were both in the moderate prevalence categories 10.18%(95% CI 6.08-13.99)and 10.11%(95% CI 5.76-14.41) and in the low category for s. *mansoni* 3.16%(95% CI 0-6.73) and 1.94%(95% CI 0.35-3.54) respectively. Overall pooled prevalence for either species increased the risk category to moderate for all strata's. Table 9 summarizes the survey results for species in each strata with the 95%CI.

Table 4.8 Infection prevalence by strata for pooled infection and individual species.

Stratum	Any Infection			S.*haematobium*		S.*mansoni*	
	+ve	Prevalence %(95% CI)	Risk Category	+ve	Prevalence %(95% CI)	+ve	Prevalence %(95% CI)
0-5km	103	12.64(7.65-17.64)	Moderate	80	10.18(6.08-13.99)	29	3.16(0-6.73)
6-15km	88	11.83(7.25-16.41)	Moderate	73	10.11(5.76-14.41)	17	1.94(0.35-3.54)
>15km	120	22.27(10.6-33.89)	Moderate	76	12.85(3.74-21.96)	52	11(1.76-20.24)

4.4 Univariate models of infection probability

To support findings from the multivaritate model univariate analysis was carried out for individual fixed effects. Results of these models can be found in tables 4.9, 4.10 and 4.11 for s. *mansoni*, s. *haematobium* and pooled species respectively.

4.4.1 Sex

Girls were found to have a significantly lower pooled infection prevalence than boys with odds ratio 0.36(95% CI:0.51-0.86), however this overall effect appeared to be driven largely by *s. haematobium* (OR=0.663, 95% CI: 0.51-0.86) rather than s. *mansoni*, for which the OR was non-significant (OR=0.808, 95% CI 0.53-1.24).

4.4.2 Age

Once again over all there was a positive linear relationship between age and pooled or s. *haematobium* infection f=6.5 p<0.05 and f=9.81 p<0.005 for pooled and s. haematobium respectively but there was no significant relationship for s. *mansoni* f=0.91 p=0.34.

4.4.3 Treatment effects

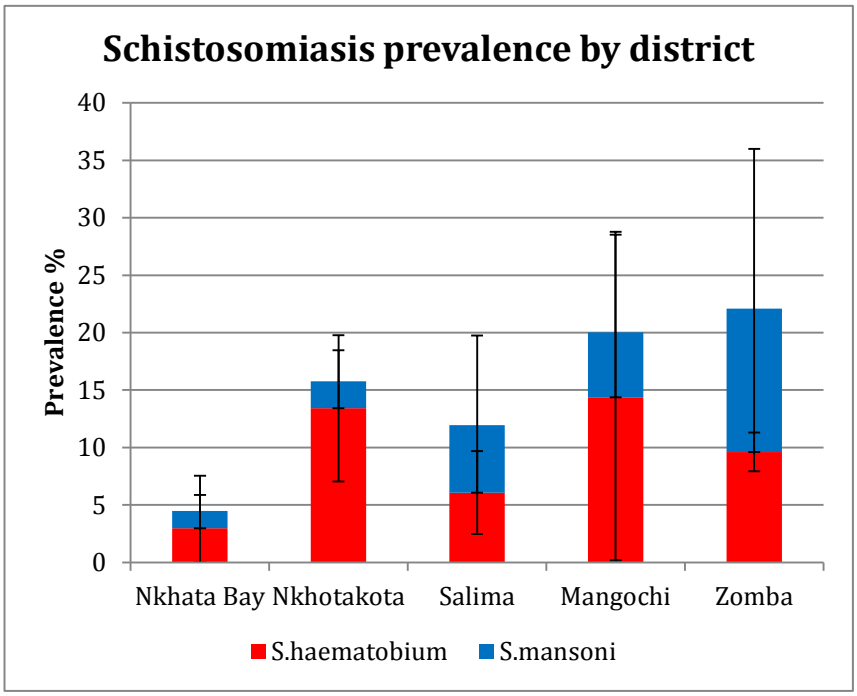
Treatment was included in the univariate analysis to determine its effects on prevalence and was not found to have a significant effect on s. *mansoni*, s. *haematobium* or pooled prevalence odds ratios 0.310(95% CI: 0.12-1.12), 1.37(95% CI: 0.71-2.66) and 0.90(95% CI: 0.46-1.76) respectively.

4.4.4 District

Variation in district prevalence was found once again when pooled species prevalance was measured or solely measured for s. *haematobium*. Continuing the trend s. *mansoni* prevalence was not found to be significantly different overall between the districts, however Nkhotakota had a significantly lower risk of infection than the other districts for s. *mansoni* OR=0.25(95%CI 0.05-0.96) p <0.05.

S. *haematobium* was found to vary significantly between the districts overall f=5.64, df=4 p<0.0005 but only Nkhata Bay had a significantly lower risk of infection OR=0.21(95% CI 0.08-0.56). Pooling the infections produced a similar result to those seen for s. *haematobium* with Nkhata Bay having the lowest risk of infection and infection prevalence varying significantly between the districts. Figure 4.2 displays the prevalence of schistosomiasis in the five districts with 95% CI bars.

Figure 4.2 Stacked bar graph showing the prevalence of each species and overall prevalence for the five mapped districts.



4.4.5 Stratum

S. *mansoni* has a significant relationship between prevalence and stratum with stratum one having a significantly lower prevalence than stratum three. This relationship however, was not repeated with s. haematobium despite following a similar trend. Figure 4.3 displays the trend in prevalence for each species between the three strata's.

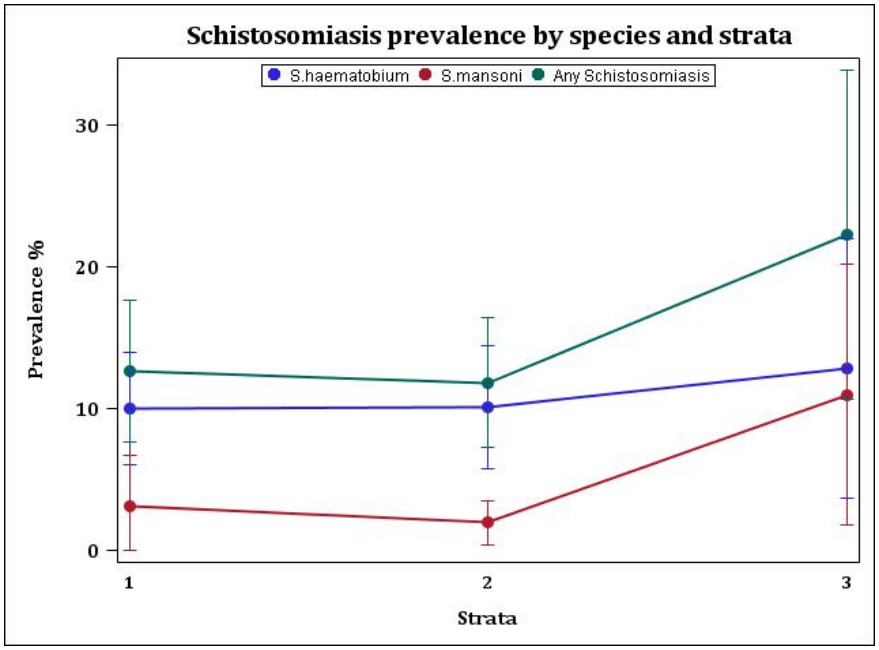


Figure 4.3. Representation of prevalence for each infection and pooled infection in each stratum.

4.4.6 Distance

Information regarding distance to lake for each school had been calculated using Arc GIS. This in turn allowed us to analyse the prevalence of each school and its distance to Lake Malawi. Using the GLIMMIX procedure without adjusting for other fixed effects, distance confirmed the results that s. *mansoni* prevalence was related to distance from lake however it was found that as you move away from the lake, risk of infection increases f=14.65 p<0.0001. This effect continues for pooled prevalence f=5.20 p<0.05, however it was no seen with s. *haematobium* f=0.09 p=0.761.

For each of the three analysis Nkhata Bay (which had the lowest prevalence overall) consistently had contradictory relationship with proximity to lake prevalence than the other districts. School prevalence with corresponding CI's were plotted against distance for each infection and fitted with a regression trend line by district and can be seen in figures 4.4, 4.5, and 4.6 for s. *mansoni*, s. *haematobium* and pooled prevalence respectively.

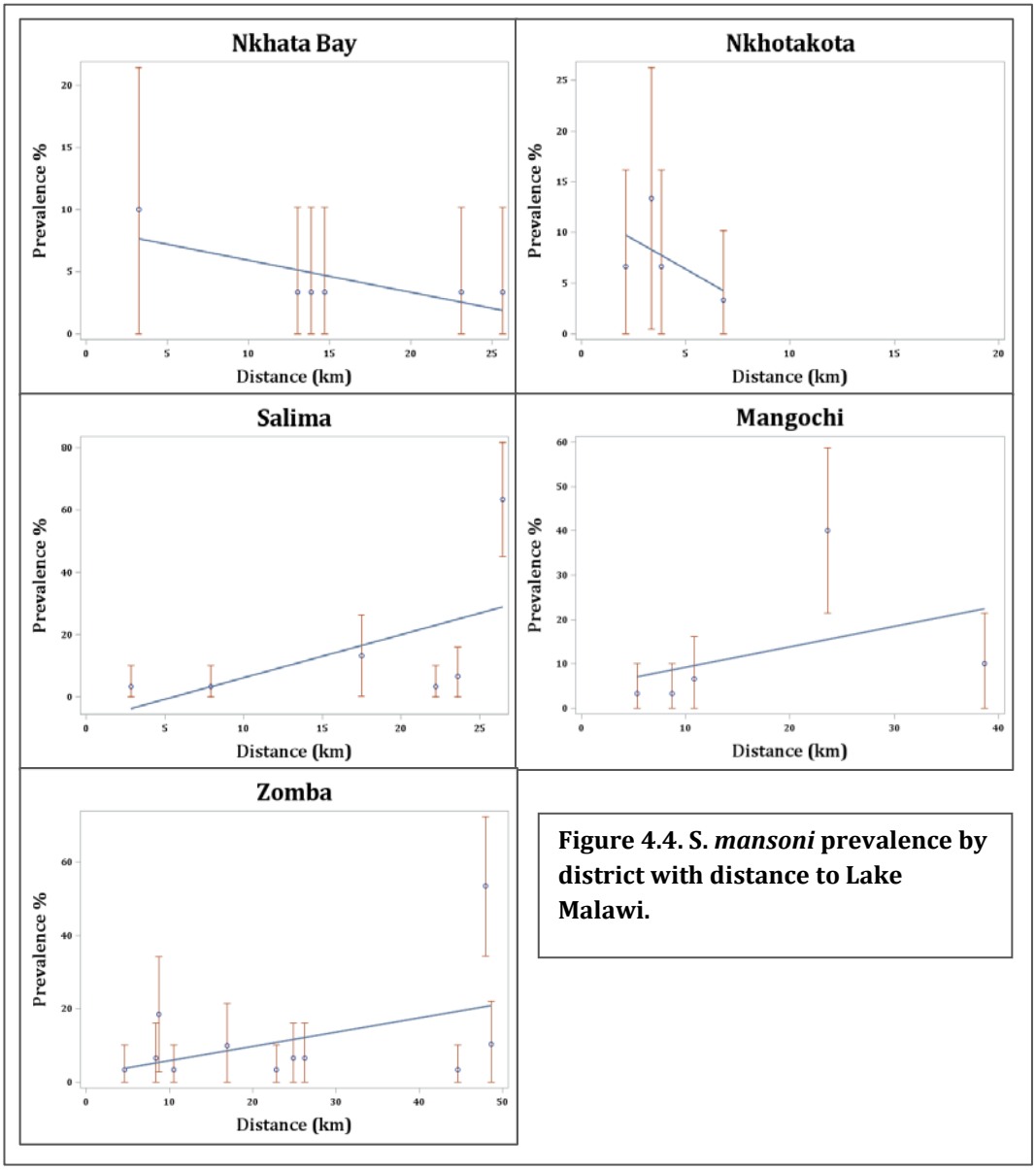


Figure 4.4. S. *mansoni* prevalence by district with distance to Lake Malawi.

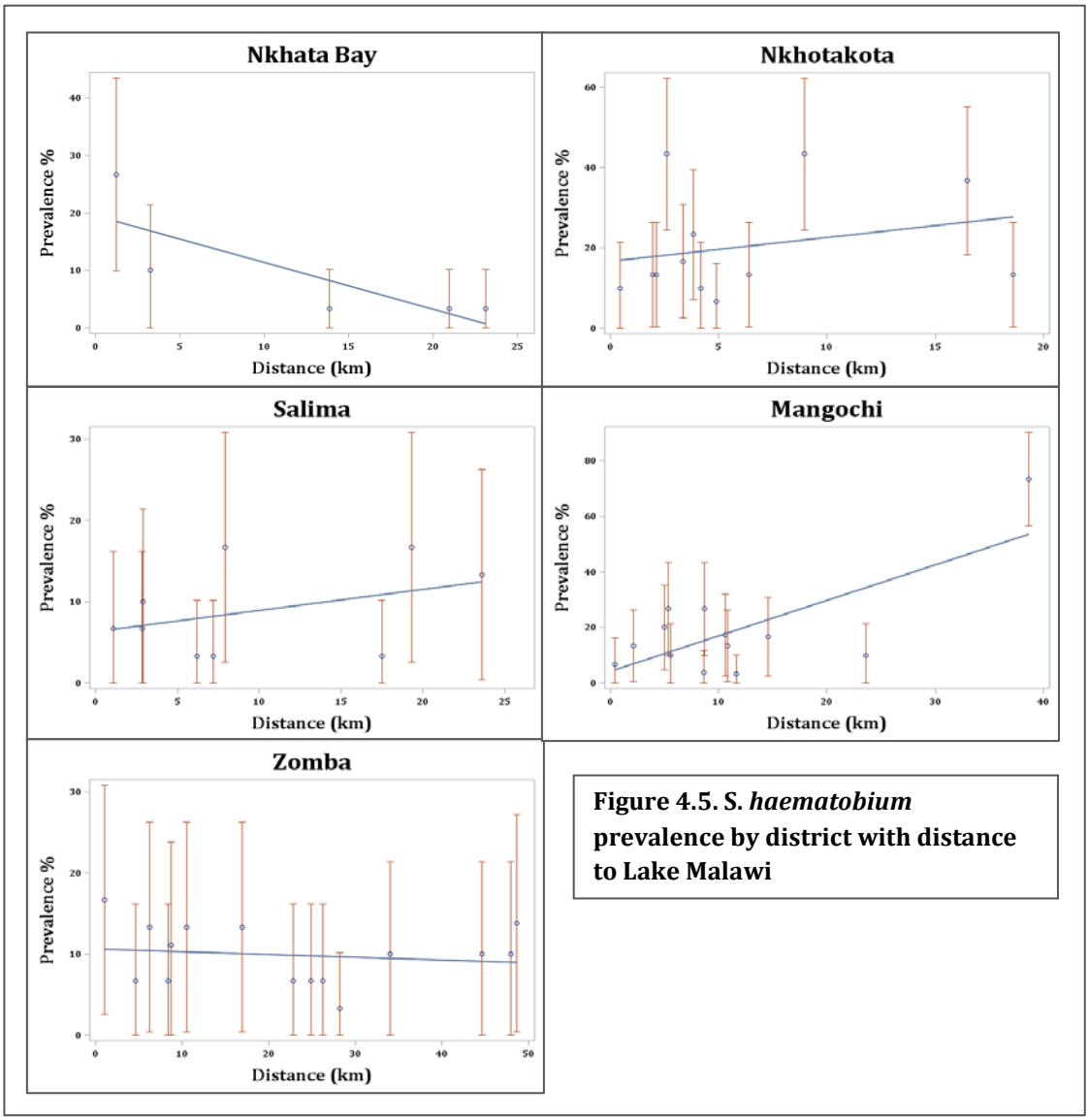


Figure 4.5. S. *haematobium* prevalence by district with distance to Lake Malawi

Table 4.9 Univariate model analysis for s.*mansoni*. Entries in bold represent the significant parameters that were included in the multivariate model.

S. mansoni	Parameter	SE	*df*	*p-value*	*F-value (Pr>F)*	Odds ratio (95% CI)
Female (reference)	-0.2135	0.219	2157	0.3297	0.95(p=0.330	Reference
Male (intercept)	-3.602	0.253	74			0.808(0.53-1.24)
Intercept	-4.6425	1.0653	74	<.0001	0.91(0.341)	
Age	0.08286	0.08691	2160	0.341		
Treatment No (Reference)	-3.4893	0.2455	72	<.0001	3.08(p=0.079)	Reference
Treatment Yes (Intercept)	-0.9928	0.5658	2136	0.079		0.310(0.12-1.12)
Intercept	**-4.587**	**0.336**	**73**	**<0.0001**	**14.65(p=0.0001)**	
Distance(km)	**0.06338**	**0.01656**	**2136**	**0.0001**		**1.065(1.03-1.10)**
Zomba (Refernence)	**-2.89**	**0.4512**	**70**	**<.0001**	**1.71 (p=0.14)**	**Reference**
Nkhata Bay	**-1.4046**	**0.7219**	**70**	**0.052**		**0.245(0.06-1.01)**
Nkhotakota	**-1.4838**	**0.7338**	**70**	**0.043**		**0.227(0.05-0.96)**
Salima	**-0.309**	**0.6596**	**70**	**0.64**		**0.734(0.20-2.68)**
Mangochi	**-1.0444**	**0.6998**	**70**	**0.14**		**0.352(0.09-1.39)**

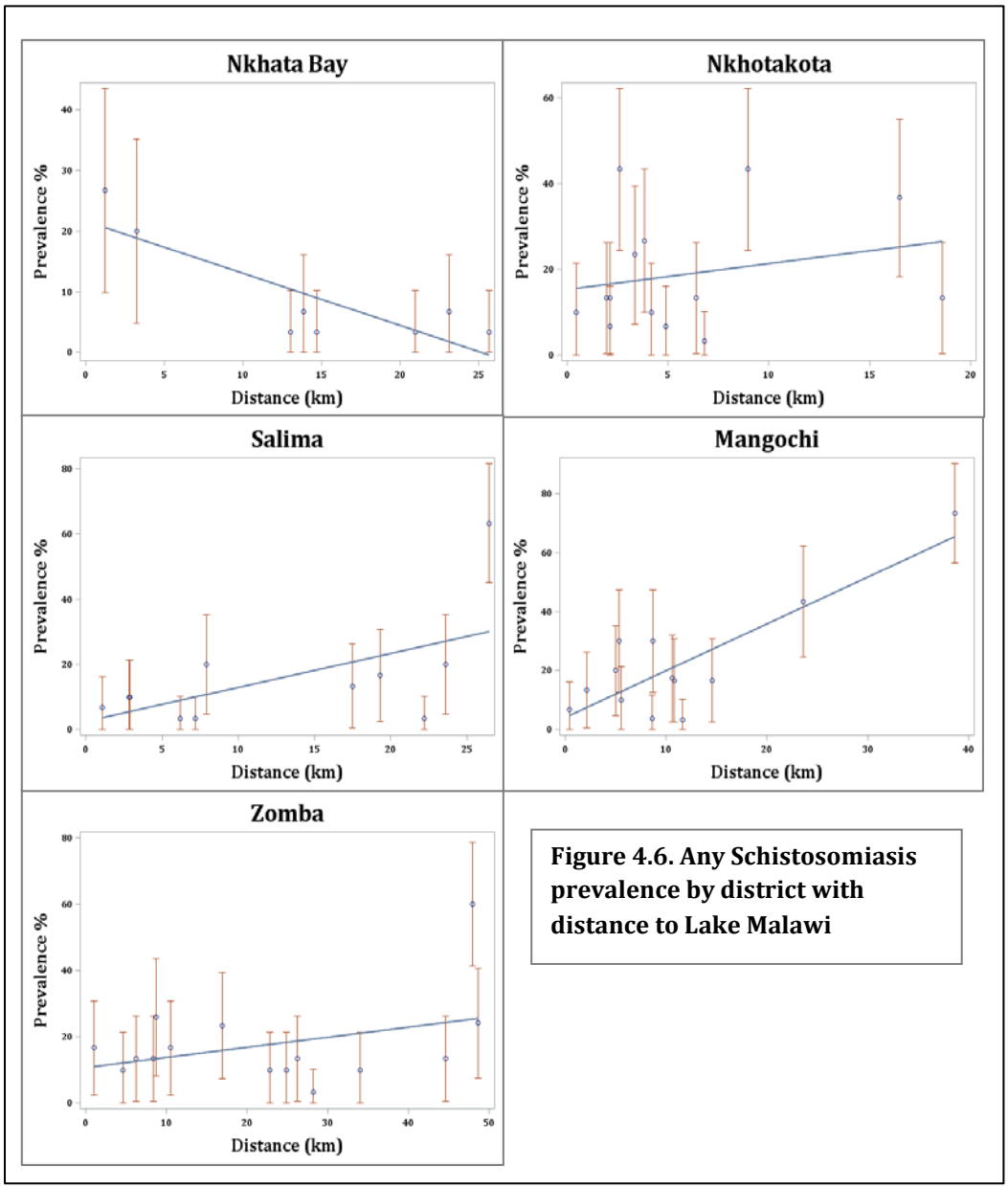


Figure 4.6. Any Schistosomiasis prevalence by district with distance to Lake Malawi

Table 4.10 Univariate model analysis for s.*haematobium*. Entries in bold represent the significant parameters that were included in the multivariate model.

S. haematobium	Parameter	SE	*df*	*p-value*	*F-value (Pr>F)*	Odds ratio (95% CI)
Female (reference)	**-0.5309**	**0.151**	**2157**	**0.0004**	**12.36(p=0.0004)**	**0.588(0.44-0.80)**
Male(intnercept)	**-2.228**	**0.16**	**74**			
Intercept	**-4.7696**	**0.7603**	**74**	**<.0001**	**9.81(p=0.0018)**	
Age	**0.1934**	**0.06174**	**2160**	**0.0018**		
Treatment No (Reference)	-2.5489	0.1734	72	<.0001	0.88(p=0.349)	Reference
Treatment Yes (Intercept)	0.3157	0.3373	2136	0.3494		1.37(0.71-2.66)
Intercept	-2.513	0.22	73	0.0001	0.09(p=0.762)	
Distance(km)	0.003839	0.01266	2136	0.7617		
Zomba (Reference)	**-2.243**	**0.2877**	**70**	**<.0001**	**5.65 (p=0.0002)**	**Reference**
Nkhata Bay	**-1.5517**	**0.4926**	**2165**	**0.0017**		**0.212(0.08-0.56)**
Nkhotakota	**0.3899**	**0.4014**	**2165**	**0.3315**		**1.477(0.67-3.25)**
Salima	**-0.7118**	**0.4336**	**2165**	**0.1008**		**0.491(0.21-1.15)**
Mangochi	**0.3638**	**0.4028**	**2165**	**0.3666**		**1.439(0.65-3.17)**

Table 4.11 Univariate model analysis for pooled infection. Entries in bold represent the significant parameters that were included in the multivariate model.

Any schistosomiasis	Parameter	SE	*df*	*p-value*	*F-value (Pr>F)*	Odds ratio (95% CI)
Female (reference)	**-0.4109**	**0.1305**	**2157**	**0.0017**	**9.91(p=0.0017)**	**0.663(0.51-0.86)**
Male(Intercept)	**-1.881**	**0.161**	**74**			
Intercept	**-3.6928**	**0.6627**	**74**	**<.0001**	**6.51(p=0.011)**	
Age	**0.1374**	**0.05385**	**2160**	**0.0108**		
Treatment No (Reference)	-2.0651	0.1708	72	<.0001	0.10(p=0.748)	Reference
Treatment Yes (Intercept)	-0.1104	0.3431	2136	0.7476		0.90(0.46-1.76)
Intercept	**-2.432**	**0.212**	**73**	**<0.0001**	**5.2(p=0.023)**	
Distance(km)	**0.02723**	**0.01194**	**2136**	**0.0227**		
Zomba (Intercept)	**-1.6647**	**0.3065**	**70**	**<.0001**	**3.71(p=0.005)**	**Reference**
Nkhata Bay	**-1.6652**	**0.4906**	**2165**	**0.0007**		**0.189(0.07-0.50)**
Nkhotakota	**-0.07354**	**0.4357**	**2165**	**0.866**		**0.929(0.40-0.22)**
Salima	**-0.4445**	**0.4458**	**2165**	**0.3188**		**0.641(0.27-1.54)**
Mangochi	**-0.05667**	**0.4378**	**2165**	**0.897**		**0.945(0.40-2.23)**

4.5 Multivariate models and interactions

General Linear Mixed Models for a binomial distribution and logistic link function were created with interactions and multiple fixed effects to determine the ultimate predictors of schistosomiasis in these five districts of Malawi. Starting with the interactions distance*district, district*treatment, water*treatment, district*sex, sex*age, and the fixed effects district, distance, sex, age, treatment and water a backwards selection process was done removing effects that had a *p* value >0.1. Tables 4.12, 4.13, 4.14 shows the respective estimate, standard error corresponding *f*-values and significance value for each species model. The small Pearson Chi-square values similar to one are indicative of that over dispersion is accounted for in these models.

4.5.1 S. *mansoni*

The final model for s.*mansoni* results as shown in table 4.12 show that a district and distance interaction predicts the prevalence of infection f=4.11 p<0.001 with Nkhotakota having a negative effect on prevalence with increasing distance compared to the other districts where prevalence increases when you move away from the lake.

Table 4.12 Results from the multivariate model for s. *mansoni*, adjusted odds ratios are not reported as they do not apply to continuous variables

Effect	Parameter	SE	*df*	*Pr > F*	*F-value (Pr>F)*
Distance*District			5	0.001	4.11(p=0.001)
Intercept	-4.4546	0.3637	69	<.0001	.
Distance*Nkhata Bay	0.0203	0.0369	2135	0.5822	.
Distance*Nkhotakota	-0.04324	0.08875	2135	0.6261	.
Distance*Salima	0.09778	0.0328	2135	0.0029	.
Distace*Mangochi	0.07114	0.03073	2135	0.0207	.
Distance*Zomba	0.05818	0.01723	2135	0.0007	.

4.5.2 S. *haematobium*

S. *haematobium* had more predictors which may be related to the higher overall prevalence. District f=5.26 p<0.005, , sex f=10.67 p<0.005 and age f=5.26 p<0.05 were all found to predictive effects of s. *haematobium* with Salima, Nkhata Bay, females and younger age groups having a negative effect on prevalence. Results of this multivariate analysis are shown in table 4.13.

Table 4.13 Results from the multivariate model for s. *haematobium*, adjusted odds ratios are not reported for age as they do not apply to continuous variables

Effect	Parameter	SE	*df*	*Pr > F*	*F-value (Pr>F)*	Adjusted Odds Ratio (95%CI)
Intercept	-4.288	0.83	70	<.0001	.	.
Nkhata Bay	-1.479	0.504	4	0.0033	5.26(p=0.0003)	0.228(0.09-0.6)
Nkhotakota	0.493	0.405	2152	0.2238	.	1.637(0.74-3.62)
Salima	-0.674	0.435	2152	0.1212	.	0.500(0.22-1.20)
Mangochi	0.304	0.404	2152	0.4525	.	1.355(0.61-2.99)
Zomba (reference)	0	.	.	.	.	Reference
Female (reference)	-0.498	0.153	1	0.0011	10.67(p=0.001)	0.607(0.45-0.82)
Male	0	.	.	.	.	.
Age	0.145	0.063	1	0.022	5.26(p=0.022)	.

4.5.3 Any schistosomiasis

Finally a model for either species was created with the results displayed in table 4.14. The interaction of distance and district f=5.04 p<0.0001 as well as sex (f=10.72, p<0.005) proved to be significant predictors of either infection. Overall if you were male living far from the lake this study suggests that you are most at risk of infection with either species of schistosomiasis.

Table 4.14 Results from the multivariate model for pooled infection, adjusted odds ratios are not reported for the interaction as they do not apply to continuous variables

Effect	Parameter	SE	*df*	*Pr > F*	*F-value (Pr>F)*	Adjusted Odds Ratio (95%CI)
Intercept	-2.6791	0.2235	5	<.0001	5.04(p=0.0001)	.
Distance*Nkhata Bay	-0.055	0.027	5	0.0438	.	.
Distance*Nkhotakota	0.058	0.036	5	0.1057	.	.
Distance*Salima	0.038	0.023	5	0.0997	.	.
Distace*Mangochi	0.073	0.021	5	0.0006	.	.
Distance*Zomba	0.028	0.011	5	0.0178	.	.
Female (reference)	-0.438	0.136	1	0.0011	10.72(p=0.0011)	0.646(0.50-0.84)
Male	.	.	.	.	.	.

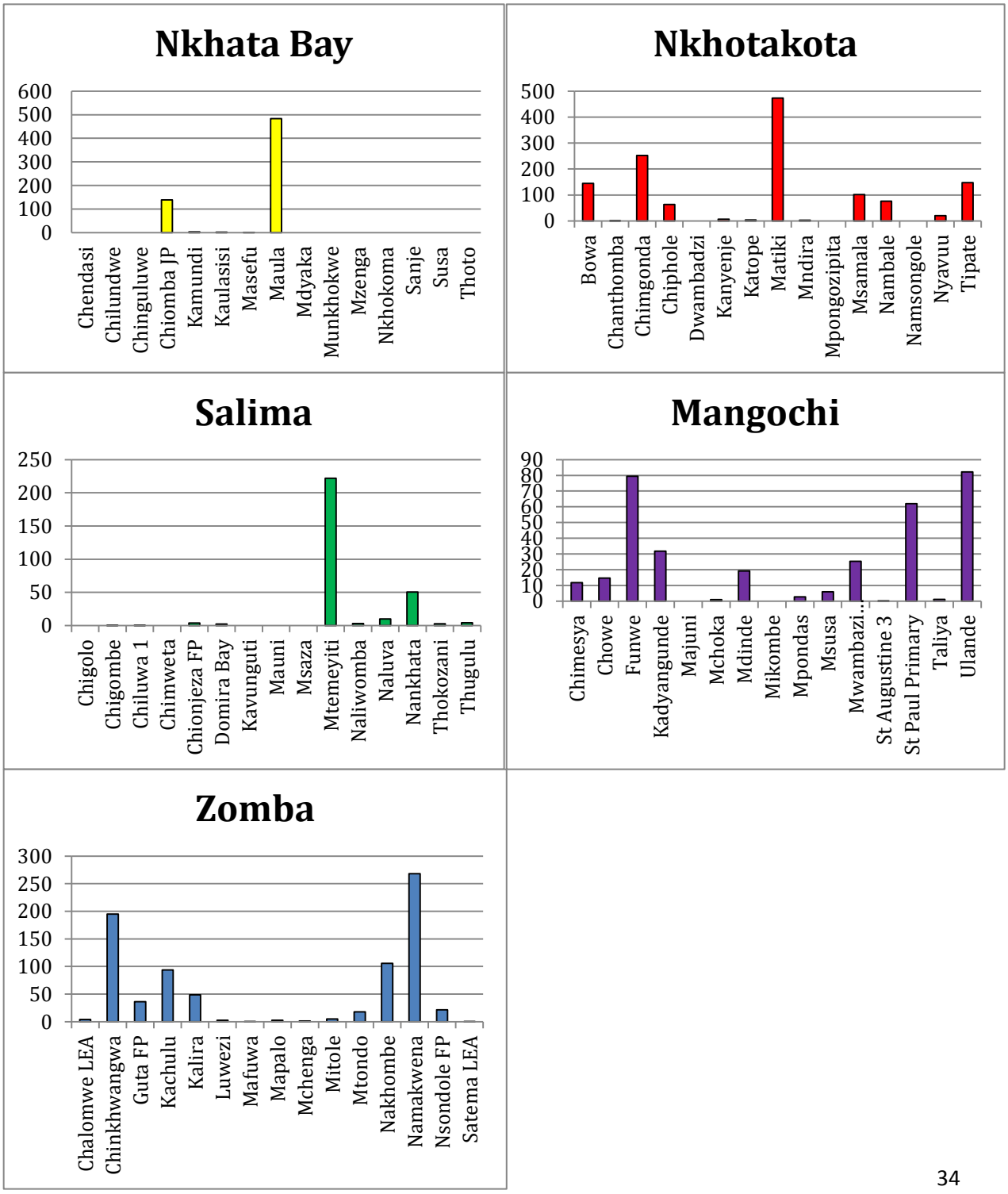
4.6 Intensity

Intensity profiles were created for each species and it was found that 21 children had high s. *mansoni* intensity infections and 46 of the 229 s. *haematobium* infections were classed as high intensity. Using the GLIMMIX procedure once again for the same variables, models were run to determine if intensity varied by district, distance to lake and most importantly treatment. None of the effects were found to be

significant predictors for intensity of infection individually or within a multivariate model. Figure 4.6 presents bar graphs documenting the mean intensity of s. *haematobium* for each school by district.

Nkhata Bay once again displays an ambiguous result with regards to intensity. Overall it has lower prevalence but two of the 15 schools (20% of infected schools) have an extremely high mean intensity compared to Mangochi which has moderate prevalence (80% of infected schools) but has no mean intensities greater than 90eggs per ml.

Figure 4.7 S. *haematobium* intensity by school for each district.



5. Discussion

It is clear with the results of this study that schisotosmisis is a still severe public health problem in Malawi. Contrary to previous studies where schistosomaisis in particular s. *mansoni* were found to have a positive significant relationship with the proximity to the great lakes I have found the reverse relationship with schools furthest from the lake having a significantly higher prevalence than those closer. This relationship however varies in strength by species and districts with Nkhata Bay district following the previously documented trends.

There are numerous possibilities as to why we have reported a new interaction and these are discussed below.

5.2 Previous District Prevalence

This study confirms that the prevalence of schistosomiasis varies greatly within a district. In 2003 the MoH carried out a small mapping survey of three districts; Mangochi, Salima and Nkhotakota. Prevalence's in Mangochi ranged from 45.9% in Makawa in 2003 to areas as low as 2%, whereas Nkhotakhota had shown consistently high prevalence estimates in studies with prevalence >30% repeatedly recorded.

Table 5.1 Community prevalence from a survey carried out by the MoH in 2003. Received from the MoH Malawi.

District	Year	Village	*S.mansoni*	*S.haematobium*
Mangochi	2003 MoH	Koche		33.8
	2003 MoH	Makawa		45.9
	2003 MoH	Ntonda		9
	2003 MoH	Nkhudzi		4
	2003 MoH	Mbwadzulu		2
	2003 MoH	Manazizi		6
	2003 MoH	Msaka		10.3
	2003 MoH	Cape Maclear		12
Nkhotkota	2010 SAC	Muyande	4.5	29.6
		Mtendere	0	63
				43
		Kasipa	0	31.8
Salima	2003 MoH	Mtiya		12.8
	2003 MoH	Chipoka 1		3
	2003 MoH	Chipoka 2		15.4
	2003 MoH	Msauka		10.3
	2003 MoH	Chimbwira		19.4
	2003 MoH	Ngodzi		30.5
	2003 MoH	Thokozani		24.7
	2003 MoH	Chikowa		20
	2003 MoH	Lifidzi		4
	2003 MoH	Mkhula		8

Table 5.1 displays previous results of mapping as done by the MoH in 2003.This current survey reports a similar disparity in prevalence within districts however it reports many more low prevalence

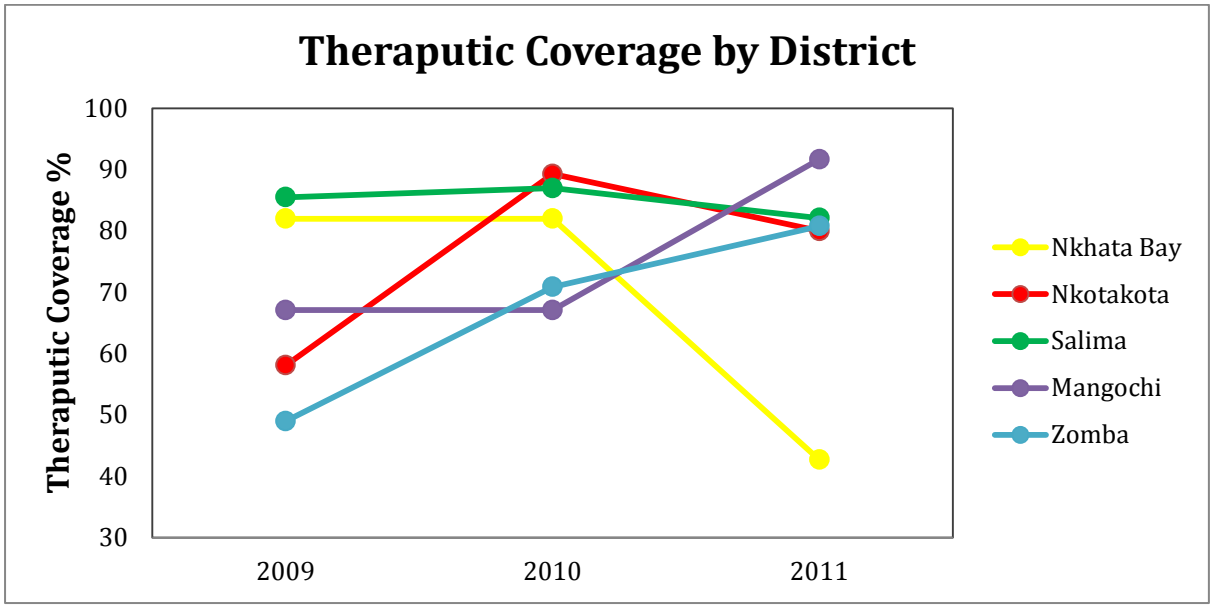
communities. As discussed below this could partly be down to the previous rounds of preventive chemotherapy however the lack of dramatic reduction to all areas having <10% prevalence could also be attributed to by varying therapeutic coverage.

5.3 Preventive Chemotherapy coverage

Based on the MoH estimates in 2003 PCT was carried out in Malawi and has been carried out once a year for the last four years in all districts. Therapeutic coverage as reported by the MoH of the five districts in this survey is shown below in figure 5.1.

Coverage was generally high with the majority of the districts reaching >70% however due to logistical problems some areas lacked adequate coverage. In Zomba for example, MDA was conducted during the school holiday or after exams where all grade 8 pupils had left school. Adverse events that occurred during the 2010 MDA contributed to the delay and by the time the strategy to reduce adverse events was agreed upon by MoH and MoE, schools were closed for the holidays.

Figure 5.1 Treatment coverage with PZQ by district for the last three years.



Further reasons for lack of coverage include funds, fuel, teacher allowances, timing of MDA near school health days, end of terms or holidays and lack of uniform reporting forms.

Interestingly Nkhata Bay which had very low coverage in 2011, had the lowest overall prevalence suggesting that MDA is not having as big an impact as in other districts or that treatment could now be localised. Zomba and Mangochi which were found to have higher prevalence's appear to be lagging in coverage however treatment in 2011 reached 80.8% and 90% respectively and with this continued coverage there could potentially be a drop in overall prevalence. Until data on individual school treatment

coverage is available we will not be able to determine the true impact preventive chemotherapy is having on the communities.

5.4 Risk factors for schistosomiasis infection

5.4.1 Sex

Concurrent with other reports the frequency of infection was significantly higher in boys (Clements et al., 2008; Naus et al., 2003). However, this only occurred when the infection was pooled as s. *mansoni* prevalence did not vary significantly by sex compared to s. *haematobium* where girls were 0.58 times less likely to be infected.

5.4.2 Proximity to Lake Malawi

The secondary aim of this study was to determine if living within close proximity to Lake Malawi a person was likely to be at a higher risk of infection and this was found not to be the case. However the significant opposing effects varies by species. S. *mansoni* infection was found to be inversely related to distance from lake and those living furthest had higher prevalence, whereas there was no significant relationship for s. *haematobium*.

In contrast to the earlier study carried out in Mangochi where Masden concluded that villages that lie on the lake shore had a higher prevalence of schistosomiasis than those inland, our results indicate that those living further from the lake shore (>15km) had a significantly higher prevalence of *s. mansoni*, and also pooled schistosomiasis but not s. *haematobium*. For s. *haematobium* district, sex and age were all determined to be significant predictors of infection. Younger boys who lived in Nkhotakota were at highest risk of S. *haematobium* infection.

Despite the presence of a great lake where s. *mansoni* has been found in abundance in other countries the overall prevalence was low with few infections. This may have contributed to the contradicting evidence from other great lake regions. A larger sample size may have found further interactions or predictors or even a different relationship. Future studies could increase sample size or have a more consistence spread of schools moving away from the lake.

5.5 Water bodies

Other explanations for the high prevalence in the far areas is that other water bodies and not necessarily the lake are the main transmission zones. Malawi has an abundance of water with over 20% of the country being covered by surface water. The snails that complete the life cycle have numerous habitats and do not rely solely on large water bodies such as the lake to breed. In fact, smaller water bodies of stagnant reedy water with vegetation are their ideal habitat. Since many areas of the lake shore are tidal with sandy shores, they do not represent areas that are suitable for the growth of snail populations. The numerous rivers in Malawi in particular the Shire River which flows through Mangochi and Zomba may in fact have a bigger influence on prevalence than the Lake.

5.6 Topography

The variation in prevalence between the districts can also be explained by the topography of the districts. Nkhata Bay for example has extreme hills at consistently high altitudes where the parasite is known not to be able to survive (John, Ezekiel, Philbert, & Andrew, 2008). These hills are wide spread throughout the district and plunge into the lake with little or no areas for reeds or muddy waters to accumulate compared to Mangochi where there are many more marsh lands and the large Shire River.

Land use also varies through the country and may account for varying prevalence's between districts. Salima and Nkhotakota are known for having an abundance of rice and sugar cane plantations and populations who work in these areas are known to at an increased risk of infection (Salehe & Hassan, 2012).

5.7 Water contact

Unusually water contact which has previously shown to significantly increase the risk of schistosomiasis infection (Kloos, Gazzinelli, & Van Zuyle, 1998; Scott et al., 2003) was shown to vary significantly between boys and girls but did not have any effect on the prevalence or intensity of infection.
Reasons for this may include misinterpretation of the questions or children not owning up to frequency of water contact due to stigma if they were well educated about high risk behaviours. Future studies would include a pilot study to determine the effectiveness of the questionnaire. If the children were well educated in the life cycle of schistosomiasis those who are at high risk of infection through water contact may be more likely to seek out treatment during the MDA therefor have a lower risk of infection.

5.8 Treatment

The lack of relationship between treatment and infection may also be due to the varying coverage in the districts and effectiveness of treatment. Furthermore, as common opinion is that the lake would be the biggest influence of infection, during the MDA there may have been much more focus in treating the communities close to the lake which may result in higher prevalence away from the lake as seen in this study. The question regarding treatment was asked to the head teacher not the individual students and we do not know if all pupils in the school were treated. Until district reports are created and we compare school prevalence and treatment coverage per school we will not know the true relationship.

6. Limitations

6.2 Non-school enrolled children

There were several limitations to this study. Firstly the lack of non-enrolled children in the sample. Due to the ease of recruitment at schools it is the norm for schistosomiasis surveys to sample children from the local primary school. However, in a country such as Malawi where the primary school enrolment is low studies miss large proportions of children. This in turn has great implications as yet again the schools are used as a base for the treatment campaigns resulting in a high probability of missing non enrolled

children. In conclusion the continued transmission we see here and high prevalence's despite treatment could partly be due to the non-treatment of non-enrolled school children who carry on the cycle. Future studies will need to include the assessment of non-enrolled children and those under five to build a true picture of prevalence.

6.3 Random selection, school distribution

Secondly the random selection of schools. This study relied on local knowledge for location of schools as there is a lack of GPS data for the schools in Malawi. The procedure of contacting head teachers and asking them to estimate the distance to the lake proved useful. The majority of schools were found to be within the correct strata, however Zomba which had the highest overall prevalence ended up with only 2 schools within strata one. This skewed distribution may have contributed to the lack of correlation of proximity and prevalence; Furthermore, two schools GPS coordinates did not correspond to a logical area on the map. Further assessment of the location of the schools will need to be done in order to improve the model and future studies.

6.4 Diagnosis

Finally, s. *mansoni* diagnosis has improved with the use of the Kato Katz technique, however, due to the aggregation of eggs the true intensity and prevalence is frequently underestimated. Similarly with s. *haematobium*, many children do not produce 10ml of urine therefore the true number of eggs again may be underestimated. These underestimations are both combated by either multiplying by 24 for s. *mansoni* or adjusting the number of eggs per ml or urine filtered. However, the true prevalence of schools and intensity of infection is likely to be underestimated. In future prevalence studies a better diagnostic test for the presence of the parasite will need to be developed to avoid missing aggregated eggs.

Increasing the number of slides read per child as well as multiple sample collections would also improve diagnosis, due to time and financial restraints this was not possible in the study.

7. Conclusion

This is the first study to look into the relationship of proximity to the lake and schistosomiasis prevalence on this scale in Malawi. The results which conclude, that as you move away from the lake you are at a significantly higher risk of infection contradicts numerous previous studies. As the previous common assumption that those near the water need more frequent treatment has proven not to be the case, The information gathered in this study will encourage the treatment programs to treat entire districts with the same integrity. With this in mind however, due to the persistent transmission and occasionally high prevalence seen in each district there must be a continued effort to maximise coverage and reach out to the groups that are continually being missed by the rounds of PCT. To reduce the transmission of schistosomiasis and avoid irreversible morbidity a continued effort must be made by all stake holders to reach the WHA goals which in turn will improve the health of thousands of Malawian children.

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Zomba District Socio-Economic Profile. (2007), (March).

Appendix a

HEADTEACHER CONSENT FORM FOR SCHOOL SURVEY OF

SCHISTOSOMIASIS AND INTESTINAL WORMS

Institutions: Ministry of Health, Lilongwe, Malawi.

schistosomiasis Control initiative (SCI), Imperial College, London.

Investigators: Mr Samuel Jemu (MoH) Dr Fiona M Fleming (SCI) and Miss Jane Whitton (SCI)

Tel: Lilongwe +265999048269

CONSENT FORM FOR INDIVIDUALS PARTICIPATING

Bilharzia, hookworms and other gut pathogens are endemic through large parts of Malawi and pose a major public health threat. As part of the Malawian national control strategy, communities at risk of infection are treated once a year for bilharzia and twice a year for soil transmitted helminths, including hookworms. The National schistosomiasis and STH Control Program of the Ministry of Health, in collaboration with the schistosomiasis Control Initiative, Imperial College, UK is extending coverage of treatment to previously un-treated areas of Malawi and to districts where there is now low endemicity of schistosomiasis following several rounds of treatment. To do this they first need to find out how many people are infected, in order to determine the treatment schedule needed in each community.

Remapping of 5 districts that have had 4 rounds of treatment will be done to determine what impact the treatment has had to determine what strategy to use in the future. We are also testing to see if by living close to a water body you are at more risk or contracting schistosomiasis and what type.

This information will also be used as part of Miss Jane Whitton's MSc Dissertation project at Imperial College London to assess the impact of MDA and a communities proximity to water bodies on the reduction of schistosomiasis and STH's.

For each child we will conduct the following:

Individuals taking part in this study will be asked questions about their name, age and sex. Individuals participating will be asked to provide one urine sample and one stool samples. Both of these may stored for future diagnostic and immunological analysis. They will also be asked a few questions about their water contact behaviour.

With your permission we will to examine 30 pupils (15 boys and 15 girls) for presence of bilharzia and hookworm infection. This information will be recorded on forms that will be kept in a locked room at the The National schistosomiasis and STH Control Program of the Ministry of Health. Only staff from the NSSCP and SCI will have direct access to the forms. The forms will be kept for the next 6 years and will then be burned. Every effort will be made to protect confidentiality of the information provided insofar as it is legally possible. With your permission, we will conduct a survey at your school. Each child will also decide and verbally indicate whether they would like to enrol in the study. His/her right for treatment will not be affected by the withdrawal.

All information will be treated as strictly confidential. The children are free to withdraw from the study at any stage without disadvantages. All school-age children will be treated for bilharzia and worms whether they are in the study group or not. For further information call Mr Samuel Jemu on +265999048269. If you agree to participate on behalf of your pupils in this important study, you are requested to say the words below and endorse them with your signature or finger-print.

"I have been explained the study objectives in a language I understand. I have asked questions and thorough explanation has been given to me. I now voluntarily agree to allow the pupils of my school to participate in this study."

SCHOOL: **SCHOOL STAMP**

HEADTEACHER'S NAME: **HEADTEACHER'S SIGNATURE**

Do you agree to the above study? Yes / No DATE: __ / __ / ____

Appendix b

DIAGNOSIS OF SCHISTOSOMIASIS AND INTESTINAL INFECTIONS

Institution: National schistosomiasis and STH Control Program, Ministry of Health, (Malawi)

CONSENT FORM FOR INDIVIDUALS PARTICIPATING

Bilharzia, hookworms and other gut pathogens are endemic through large parts of Malawi and pose a major public health threat. As part of the Malawian national control strategy, communities at risk of infection are treated once a year for bilharzia and twice a year for soil transmitted helminths, including hookworms. The National schistosomiasis and STH Control Program of the Ministry of Health, in collaboration with the schistosomiasis Control Initiative, Imperial College, UK is extending coverage of treatment to previously un-treated areas of Malawi and to districts where there is now low endemicity of schistosomiasis following several rounds of treatment. To do this they first need to find out how many people are infected, in order to determine the treatment schedule needed in each community.

Remapping of 5 districts that have had 4 rounds of treatment will be done to determine what impact the treatment has had to determine what strategy to use in the future. We are also testing to see if by living close to a water body you are at more risk or contracting schistosomiasis and what type.

This information will also be used as part of Miss Jane Whitton's MSc Dissertation project at Imperial College London to assess the impact of MDA and a communities proximity to water bodies on the reduction of schistosomiasis and STH's.

Individuals taking part in this study will be asked questions about their name, age and sex. Individuals participating will be asked to provide one urine sample and on stool sample. Some of these may stored for future diagnostic and immunological analysis. They will also be asked a few questions about their water contact behaviour.

All information will be treated as strictly confidential. You are free to withdraw from the study at any stage without disadvantages. All community members will be treated for bilharzia and worms whether they are in the study group or not. For further information call Mr Samuel Jemu on +265999048269. If you agree to participate in this important study, you are requested to say the words below and endorse them with your signature or finger-print.

"I have been explained the study objectives in a language I understand. I have asked questions and thorough explanation has been given to me. I now voluntarily agree to participate in this study."

Name…… Signature/Fingerprint……

Date……. Date……..

Interpreter's Name……Interpreter's Signature ……

Appendix c

Pupil water use form

ID Number : (DDD.SSS.NN)	|__|__|__|.|__|__|__|.|__|__|
Date of Survey (DD.MMM.YYY)	|__|__|.|__||__|__|.|__|__|__|__|
Interviewer initials	|__||__|__|
*DDD - admin level 2 code, SSS - school code, NN - ID number	

Questions					
	Every day	4-7 times a week	1-3 times a week	Sometimes	Never
Do you swim in the lake/river?					
Do you collect water from lake/river?					
Do you use the lake/river for; bathing					
playing					
washing clothes					
fishing					
gardening					

	Yes	No	I don't know
Did you receive tablets last year?			

ID Number : (DDD.SSS.NN)	|__|__|__|.|__|__|__|.|__|__|
Date of Survey (DD.MMM.YYY)	|__|__|.|__||__|__|.|__|__|__|__|
Interviewer initials	|__||__|__|
*DDD - admin level 2 code, SSS - school code, NN - ID number	

Questions					
	Every day	4-7 times a week	1-3 times a week	Sometimes	Never
Do you swim in the lake/river?					
Do you collect water from lake/river?					
Do you use the lake/river for; bathing					
playing					
washing clothes					
fishing					
gardening					

	Yes	No	I don't know
Did you receive tablets last year?			

Appendix d

ICOSA M&E Participant Identification Form

Date of Survey	*(DD-MMM-YYYY)*	|___|___|-|___|___|___|-|___|___|___|___|	Registers Initials	|___|___|___|
District (Admin 2) Name				
District (Admin 2) Code		|___|___|	Survey Type	
School Name				
School Code		|___|___|___|	Page Number	

Participant Identification Form

	Name	Identification Number
1.		|___|___|___|.|___|___|___|.|___|___|
2.		|___|___|___|.|___|___|___|.|___|___|
3.		|___|___|___|.|___|___|___|.|___|___|
4.		|___|___|___|.|___|___|___|.|___|___|
5.		|___|___|___|.|___|___|___|.|___|___|
6.		|___|___|___|.|___|___|___|.|___|___|
7.		|___|___|___|.|___|___|___|.|___|___|
8.		|___|___|___|.|___|___|___|.|___|___|
9.		|___|___|___|.|___|___|___|.|___|___|
10.		|___|___|.|___|___|___|.|___|___|___|
11.		|___|___|___|.|___|___|___|.|___|___|
12.		|___|___|___|.|___|___|___|.|___|___|
13.		|___|___|___|.|___|___|___|.|___|___|
14.		|___|___|___|.|___|___|___|.|___|___|
15.		|___|___|___|.|___|___|___|.|___|___|
16.		|___|___|___|.|___|___|___|.|___|___|
17.		|___|___|___|.|___|___|___|.|___|___|
18.		|___|___|___|.|___|___|___|.|___|___|
19.		|___|___|___|.|___|___|___|.|___|___|
20.		|___|___|___|.|___|___|___|.|___|___|

Appendix e

ICOSA- PCE Pupil Form

ID Number:	*(DDD.SSS.NN)**	|___|___|___|.|___|___|___|.|___||___|
Date of survey	*(DD-MMM-YYYY)*	|___|___|-|___|___|___|-|___|___|___|___|
Interviewer initials		|___|___|___|
***DDD – admin level 2 code, SSS – school code, NN – ID number (00-99)**		

A. Individual

1. First name		
2. Surname		
3. Sex	*1=Male 2=Female*	|___|
4. Grade	*1 = One 2 = Two 3 = Three 4 = Four 5 = Five 6 = Six 7 = Seven*	|___|
5. Age	*(years)*	|___|___|
6. How long have you lived here?	*(years)*	|___|___|

C. Kato Katz

Date *(DD-MMM-YYYY)*	|___|___|-|___|___|___|-|___|___|___|___|		Notes	
Slide	*Day 1 Slide A*	*Day 1 Slide B*	*Day 1 Slide A*	*Day 1 Slide B*
Microscopist initials	|___|___|___|	|___|___|___|		
S. mansoni*	|___|___|___|	|___|___|___|		
Hookworm*	|___|___|___|___|	|___|___|___|___|		
Ascaris*	|___|___|___|___|___|	|___|___|___|___|___|		
Trichuris*	|___|___|___|___|	|___|___|___|___|		

*Egg count per slide i.e. do not multiply by 24; ensure zero counts are recorded; if missing leave blank.

D. Urine Filtration and Dipstick Result

Date	*(DD-MMM-YYYY)*	|___|___|-|___|___|___|-|___|___|___|___|
Egg Count Slide 1	|___|___|___|___|	Volume of urine (ml) |___||___|.|___|
Egg Count Slide 2	|___|___|___|___|	Volume of urine (ml) |___||___|.|___|
Dipstick result	*0 = none 1 = trace non-haemolysed 2 = trace haemolysed 3 = + 4 = ++ 5 = +++*	|___|
Visible Haematuria	*0 = No 1 = Yes*	|___|

Appendix f

ICOSA- Water and Sanitation Form					
School details					
Date of visit	*(DD-MMM-YYYY)*	|___|___|-|___|___|___|-|___|___|___|___|			
Team Leader Initials	|___|___|___|		District code	*(DDD)*	|___|___|___|
School Name			School code	*(SSS)*	|___|___|___|
DDD – Admin level 2 code, SSS –school code					

Water and Sanitation Information				
	Boys	Girls	Staff Male	Staff female
1. Number of people				
2. Number of latrines				
Accessibility				
3. Distance from users (classrooms) to latrines (m)				
4. No. of toilets separated for male and female by solid walls (not lightweight partitions)				
Privacy and security				
5. No. of latrines without doors				
6. No. of latrines where people inside is visible from the outside				
7. No. of latrines with risk of falling into the pit (no cover on the hole)				
Condition of latrines				
8. No. of latrines being used				
9. No. of latrines broken				
10. No. of latrines overgrown				
11. No. of latrines clean (floor and wall free of excreta)				
12. Is anal cleansing material available at all times?				
Type of latrine				
13. No. of latrines with solid slab (Cement or hardwearing material that you can easily clean)				
14. No. of latrines with solid walls (Cement or similar, not lightweight partitions)				
15. No. of latrines with roof preventing water from getting in				
16. No. of latrines with a net-covered ventilation shaft or window at the top				
17. No. of latrines with bowls or urinals				
Handwashing facilities and water				
18. No. of handwashing points available and fully operating (in case of shared facility, assign it to one of the columns, do not repeat numbers)				

19. No. of hand washing facilities with water always present for hand washing				
20. No. of hand washing facilities with a correct drainage system in place (no puddles)				
21. Distance from latrine to hand washing facilities				
22. Do the hand washing facilities have soap?				
23. Is clean drinking water available at the school?				
Cleaning and maintenance				
24. Who is responsible for the cleaning and the maintenance of the latrines and hand washing facilities?				
25. Are there enough and appropriate cleaning tools and products available for this task at school?				
26. How often is the cleaning done? (days)				
Awareness				
27. Are children using open defecation at school? 28. Do children reportedly wash hands after using the latrines and before meals?				

Appendix g

ICOSA- Mapping and PCE School Form

Date of visit	*(DD-MMM-YYYY)*	|___|___|-|___|___|___|-|___|___|___|___|	Reporters Initials	|___|___|___|

A. Site Details

1.	Province (Admin level 1)		
2.	District (Admin level 2)		
3.	District (Admin level 2) Code	*(DDD)*	|___|___|___|
4.	Sub-district (Admin level 3)		
5.	Community (Admin level 4)		

B. GPS (at time of…)

1.	Arrival decimal degrees **east**	|___|___|___|.|___|___|___|___|___|___|___|___|___|___|
2.	Arrival decimal degrees **south**	|___|___|___|.|___|___|___|___|___|___|___|___|___|___|
3.	Departure decimal degrees **east**	|___|___|___|.|___|___|___|___|___|___|___|___|___|___|
4.	Departure decimal degrees **south**	|___|___|___|.|___|___|___|___|___|___|___|___|___|___|

C. School details

1.	School Name		
2.	School Code	*(SSS)*	|___|___|___|
3.	Name of Headmaster		
4.	Contact Number of Headmaster		
5.	Have pupils in your school received deworming treatment in the last year?	*1=Yes* *0=No* *2=Don't know*	|___|
6.	Lowest Grade taught	*1=One 5=Five* *2=Two 6=Six* *3=Three 7=Seven* *4=Four*	|___|
7.	**Highest** Grade taught	*1=One 5=Five* *2=Two 6=Six* *3=Three 7=Seven* *4=Four*	|___|

D. Enrolment numbers

	Boys Enrolled	**Girls** Enrolled
Total	1. |___|___|___|___|	2. |___|___|___|___|
Grade 1	3. |___|___|___|	4. |___|___|___|
Grade 2	5. |___|___|___|	6. |___|___|___|
Grade 3	7. |___|___|___|	8. |___|___|___|
Grade 4	9. |___|___|___|	10. |___|___|___|
Grade 5	11. |___|___|___|	12. |___|___|___|
Grade 6	13. |___|___|___|	14. |___|___|___|
Grade 7	15. |___|___|___|	16. |___|___|___|