

## Prevalence and Intensity of Infection of Intestinal Schistosomiasis and Reinfection after Intervention in Budalangi Endemic Focus of Western Kenya

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**Abstract:** Human schistosomiasis or bilharziasis is a water borne disease of man caused by trematodes of the genus *Schistosoma* and transmitted by fresh water snails. It is one of the most widespread parasitic infections being second only to malaria in its socioeconomic and public health importance in tropical and subtropical areas. Intestinal schistosomiasis is endemic only in areas with certain physical characteristics and risk factors. A 2 years study was conducted in the Budalangi endemic focus of Western Kenya to determine prevalence and intensity of infection and reinfection in the risk population with a view of instituting a deworming programme in primary schools. Stool samples collected from 972 school children aged 5-14 years in 18 randomly selected schools were examined for ova of *S. mansoni*. A questionnaire was used to obtain demographic information and to quantify exposure to infested surface waters. The mean prevalence of infection in all schools (32.1%; range 0.0-65.0%) was significantly higher in females (58.0%) than in males sampled (42.0%) ( $\chi^2$ ;  $p < 0.05$ ). Intensity of infection was predominantly light with 65.1% of the infected population harbouring GMEC 1-99 epg. The prevalence of infection significantly varied with age groups ( $\chi^2$ -test;  $p < 0.05$ ). The 8-11 years age group accounted for 49.5% of the potential contamination of contact sites by ova of *S. mansoni*. The prevalence and intensity of infection significantly dropped (Studentised t-test;  $p < 0.05$ ) after treatment with praziquantel coupled with training in primary hygiene. Proximity to the lake shoreline ( $R^2 = 0.89$ ,  $p < 0.05$ ), contact with lake water ( $\chi^2$ ;  $p < 0.05$ ) and specific water-related activities including swimming (OR = 1.70; 95% CI = 1.03-2.81), fishing (OR = 3.23; 95% CI = 1.70-6.15) and washing clothes in the lake (OR = 2.07; 95% CI = 1.27-3.38) were all associated with high risks of infection. The studies showed that there was a continuous low level of transmission of *S. mansoni* in the study area among the various exposure groups attributable to inevitable contact with permanent water bodies which the vector snail used for breeding. The level of infection in the human population determined in these studies could be used for planning and implementing combined mass treatment of people who reside in the study area in order to enhance control of the parasite.

**Key words:** Intestinal schistosomiasis, prevalence, intensity, deworming, reinfection

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### INTRODUCTION

Human schistosomiasis or bilharziasis is an ancient water borne disease of man caused by trematodes of the genus *Schistosoma*. It is transmitted by fresh water snails with typical eggs having been recovered from both Chinese and Egyptian mummies (Farooq, 1973). It is one of the most widespread parasitic infections being second only to malaria in its socioeconomic and public health importance in tropical and subtropical areas (Loum, 1974).

Schistosomiasis infections have contributed substantially to the burden of disease in sub-Saharan Africa. Convincing evidence that the disease causes any significant loss is hard to come by because exact figures

are difficult to derive. However, conservative reports have indicated that the disease afflicted over 200 million people worldwide with up to 168-187 million of these being in Africa alone (WHO, 1993, 1997; Chan *et al.*, 1994; De Silva *et al.*, 2003). In addition, a further, 500-600 million people have been reported to be at a constant risk of the infection annually (Chitsulo *et al.*, 2000; Engels *et al.*, 2002).

In Kenya, endemic foci of human intestinal schistosomiasis have been identified as being in Machakos, Kitui, Kirinyaga, Murang'a and Meru districts (Mutinga and Ngoka, 1971; Highton, 1974; Mutahi and Thiongo, 2005), in Taita Taveta at the coast (Thiongo and Ouma, 1987; El Kholy *et al.*, 1989), around Lake Jibe and Lake Victoria and more so in Bunyala and Samia locations

in Busia district (Masaba, 1978). Currently, Bunyala and Samia locations are administratively in Bunyala and Funyula districts, respectively.

The epidemiology of schistosomiasis is known to be influenced by the type of water contact patterns, sewage disposal (Esrey and Habicht, 1986; Esrey *et al.*, 1985; 1991), the biology and distribution of potential snail hosts (Vogel *et al.*, 1982) and the role of reservoir hosts (McCullough *et al.*, 1972). Iarotski and Davis (1981) reported that there was little information on the world prevalence, morbidity and mortality on which planning and implementation of control measures could be based. Knowledge concerning the epidemiology of human schistosomiasis provides an essential background for the planning and implementation of control measures or for the prevention of the introduction of the infection into schistosomiasis non-endemic areas. In earlier studies by McCullough and Malorn (1974) and Esrey (1996), it was vividly demonstrated that viable and sustainable schistosomiasis control would not be tenable in background absence of information on the epidemiology of the disease.

For communities living near Lake Victoria, frequent contact with lake water cannot be avoided, let alone being limited. This played a crucial role in the predisposition of the people to infection and re-infection with schistosomiasis since, the more contacts they made the higher was the likelihood of hosting more adult worms and so was the number of eggs laid by the worms. The community from which the present study participants were obtained was therefore endemically exposed to schistosomiasis cercariae due to the relatively prolonged duration of contact with snail infested fresh lake water, the River Nzoia and other related exposure sites. Differences existed in the duration of contact with water among the local people, the time of the day on which contact was made and individual immunity and general health; given that the area was endemic to malaria and had high HIV-1 prevalence levels. Therefore, it was justifiable to determine the dynamics of the infection using data drawn both from the human population to elucidate the possible causes of the observed re-infection trends, alongside the role played by the worm burden as bases for developing a more successful and meaningful control programme given that contact with water was inevitable for most members of the community under study.

The present study was thus designed to provide data that would aid in instituting targeted control strategies in the common human-water contact sites in the flood plains of Budalangi as part of a baseline prototype survey for a planned Nationwide Primary Schools Deworming Programme (NPSDP). The goal of the study was to

determine the rates of infection and reinfection so as to aid in understanding the observed prevalence rates and guide targeted control measures.

## MATERIALS AND METHODS

**Study area:** The study was conducted between May 2006 and July 2008 in Budalangi Division in Busia County in the expansive Lake Basin of Western Kenya. The division (latitude 0°35', 0°74'N; longitude 34°09' and 34°43'E; altitude 1130-1463 m above sea level) is bordered by Funyula to the North East, Ugenya to the North West and Bondo to the West, Alego-Usonga to the South West and Lake Victoria to the South East. Budalangi division has an approximate area of 1262 km<sup>2</sup> which includes 137 km<sup>2</sup> under a permanent water surface.

**Research design:** Field and laboratory work involved collection of stool samples from children of primary school going age and processing them using Kato thick smear technique and administration of questionnaires. The research project was phased out for a period of 24 months within which period data on various variables was collected. Ethical consideration was sort for the use of human subjects, protection of human subjects strictly adhered to and prior informed consent before any sampling and questionnaire administration. An inclusion and exclusion criterion was decided upon before start of sample collection.

**Selection of the study sample:** All ECD to standard five pupils who attended primary schools in Bunyala District during the time of data collection between May and November 2006 participated in the study. The study sample was selected using a stratified multi-stage probability sampling technique.

First, the district was stratified into three ecological risk areas for intestinal schistosomiasis based on the relative distance from Lake Victoria as follows; high risk stratum (<3 km), moderate risk stratum (3-5 km) and low risk stratum (>5 km). STATA Software V10.1 (Stata Corp Ltd. Texas, USA) was used to estimate sample size for comparison of proportions between strata. The sample size of 972 was estimated using a prevalence estimate of 30.0 with 80.0% power to detect a relative difference of 10.0% between strata at a 0.05 level of significance.

Secondly, the number of schools and population estimates of the pupils in each stratum was obtained from the district education offices in Busia. Based on the population distribution of the pupils within the strata and the prior decision to randomly select 54 pupils in all the selected schools it was calculated that 18 schools would

be required under a Lot Quality Assurance Scheme approach as described by Karanja. Thirdly, sampling was conducted in two stages. In the first stage, the primary sampling units were schools that were selected with a probability proportional to number of schools in the strata. A list of schools in each stratum was compiled and using computer generated random numbers, schools in each stratum were selected as follows; four schools from the high risk stratum, six from the moderate risk stratum and eight from the low risk stratum.

In the second stage a random sample of at least 54 pupils in each selected school was obtained. This translated to 3 pupils per class in 18 schools so that the total universe of sampling was 972 pupils for subsequent studies. Based on the study design of the survey; weighting, stratification and clustering were taken into account in all statistical analyses using survey procedures in SAS.

**Use of questionnaires:** Structured and contingency questionnaires were used to collect data both from the pupils at school and the parents at household level in order to determine the risk factors for human intestinal schistosomiasis in the study area. To reduce bias and improve on the performance of the questionnaires, questions about schistosomiasis were disguised among other health related questions.

The parameters prompted for in the questionnaires in both cases included knowledge of and the main factors that disposed individuals to intestinal schistosomiasis including: the main household water source; child's knowledge of nearby open water sources (open water source being defined as any open water body including lakes, springs, rivers, streams, ponds, swamps and dams); frequency of contact with open water sources; passing blood in stool in the recent past; history of *S. mansoni* infection and *S. mansoni* treatment; urban or rural location; proximity of the school to an open water source and household Socio-Economic Status (SES).

The questionnaires were pre-tested and modified accordingly after discussions with the field research assistant for the project, field officers working for two NGOs namely ICS and IPAK, teachers and the district health officials. For each location, 100 questionnaires were administered in the local language by a trained interviewer giving a total of 600 questionnaires for all the six locations sampled. Pupils were at every outset required to complete an elaborate questionnaire which was later matched with a household questionnaire.

Water contact was categorized as none, some or frequent contact and matched with the type of activity such as swimming, fishing, bathing or collecting water for

household use. The pupils were also asked whether they noticed any blood in their stool during the previous 1 month.

**Collection of stool samples from school children:** Stool samples were collected from pupils for later processing for ova of *S. mansoni* in the laboratory to quantify prevalence and intensity of the infection. Pupils from randomly selected study schools were assigned numbers. The desired study group was then randomly selected. Each selected pupil was given a sample container with a screw top in which the morning stool sample was collected.

Approximately, 10 g of fresh stool was required for each sample during every visit to the schools. The sample container was then labelled with the pupil's ID code, the date and time of collection and then stored in a cool box for transportation to the local DVBD laboratory for processing.

**Processing of stool samples:** It was necessary to process stool samples to make slides for microscopic examination of ova of *S. mansoni* in the laboratory using the modified Kato Method. Each specimen was prepared in duplicate and slides read across all fields to quantify intensity of infection for eggs of *S. mansoni* based on WHO thresholds as depicted:

- Light infestation: 1-99 eggs per gram (epg) of stool
- Moderate infestation: 100-499 epg of stool
- Heavy infestation: >500 epg of stool

Quality assurance was provided by an independent slide reader for 10% of the prepared slides randomly chosen using computer generated random numbers.

**Intervention and reinfection studies:** Pupils in the study were monitored for *S. mansoni* after several packages of intervention at the end of the study so as to determine the effect of single or a combination of intervention packages in *S. mansoni* reinfection that would be used for a large scale control programme at a later stage. After 6 months of sampling all the pupils in the survey schools were re-enumerated for the intervention studies. The schools were divided into groups as follows:

- Group I schools did not receive any treatment nor hygiene education (control)
- Group II schools received deworming treatment for schistosomiasis using Praziquantel (PZQ), the drug of choice

- Group III schools received hygiene education only
- Group IV schools received hygiene education plus PZQ

Hygiene education was given by personnel trained in Participatory Rural Appraisal (PRA) and Participatory Health and Sanitation Transformation (PHAST) packages drawn from ICS a local NGO and personnel from the local Ministry of Health based at Port Victoria Sub District Hospital and the DVBD. All the pupils enlisted for the studies were resurveyed after 18 months to determine the prevalence as indicated earlier. Mass treatment was administered to all pupils at the end of the project using the recommended dosage of 40 mg kg<sup>-1</sup> body weight.

## RESULTS

**Parasitological results:** Data on the infestation of schistosomiasis in various exposure groups is presented in Table 1. The results showed that the overall prevalence of *S. mansoni* in 972 pupils of all the 18 schools sampled was 32.1% with a range of 0.0-65.0%. There was no significant difference (p>0.05) in the prevalence rate of *S. mansoni* infection among the schools surveyed. The foregoing observation signified a uniform occurrence of a low to moderate *S. mansoni* infection in Budalangi division of Bunyala district. It was shown that prevalence rapidly increased from 4.5% in the <5 years age group to 26.3% in the 5-8 years age group and peaked off at 42.3% in the 8-11 years age group. The increase in prevalence occurred despite the fact that the mean age was 10.5 years with 86.2% of the pupils being found in the third category. It was further observed that the prevalence of infection dropped off sharply to 26.9% in pupils aged 11-14 years and was significantly different ( $\chi^2$ -test; p<0.05) between the age groups. The age group 11-14 years was found to account for 49.5% of the potential contamination by ova of *S. mansoni* based on the calculation of the crude and relative Index of Potential Contamination (IPC) for the study population (Table 2).

Table 1: Age specific prevalence and mean egg counts of intestinal schistosomiasis in 972 school children in 18 schools

Parameters	Age groups (Number in group)				Total (n = 972)
	<5 years (n = 80)	5-8 years (n = 260)	8-11 years (n = 374)	11-14 years (n = 370)	
Heavy inf. (%) <sup>a</sup>	22.20	27.800	38.900	11.100	5.800
Moderate inf. (%) <sup>a</sup>	6.600	36.300	27.500	29.700	29.20
Light inf. (%) <sup>a</sup>	2.000	21.700	49.300	27.100	65.10
Total (%)	4.500	26.300	42.300	26.900	32.10
<sup>b</sup> GMEC egg±SE	59±14	106±19	118±24	76±16	90±18

<sup>a</sup>Expected values <5; categories merged into 2 and Yates correction performed for 1 degree of freedom, <sup>b</sup>WHO threshold for schistosomiasis is Heavy infection = 500<sup>c</sup> epg; Moderate infection = 100-499 epg and Light infection ≤99 epg. <sup>b</sup>GMEC epg = Geometric Mean Egg Count (GMEC) expressed as epg per gram (epg) of stool, SE = Standard Error

This implied the likelihood of many of the children within this particular age group developing severe schistosomiasis.

*S. mansoni* infections were predominately light with 65.1% of all the infected children having 1-99 GMEC epg, while 29.2% were recorded as being moderate with 100-499 GMEC epg while a mere 5.8% were shown to be heavy infections (>500 GMEC epg) (Table 3). This denoted some kind of relationship between the prevalence and intensity of the infection even though it was apparently very weak. The data collected showed that prevalence was markedly high in females (58.0%) as compared to males (42.0%) regardless of age. The variation in prevalence between male and female pupils was statistically significant ( $\chi^2$ -test; p<0.05) implying that females had more contact with snail infested habitats than the males.

Other results showed that the prevalence of infection among the pupils decreased with increasing distance from Lake Victoria (Table 4). The schools that were nearest to the lake (within 3 km) had a prevalence of infection of 71.2% while at the distance of up to 5 km from the lake, the prevalence rate decreased to approximately 41.3% at a distance of up to 5 km from the lake. At over 5 km from the shoreline, the prevalence of infection in schools dropped sharply to 5.5%.

Table 2: Calculation of the Index of Potential Contamination (IPC)

Age groups	Prevalence (%) A	Intensity (GMEC-epg) = B	Crude IPC = C = A×B	Relative IPC = C/10089.1
<5 years	4.5	59	265.5	2.6
5-8 years	26.3	106	2787.8	27.6
8-11 years	42.3	118	4991.4	49.5
11-14 years	26.9	76	2044.4	20.3
Total	-	-	10089.1	100.0

Table 3: Prevalence and mean egg counts of intestinal schistosomiasis in 972 school children in 18 schools by gender

Attributes	Males (%) n = 526 (54.1)	Females (%) n = 446 (45.9)	Total (%) n = 972 (100)	p-level ( $\chi^2$ -test <sup>c</sup> )
Heavy inf. (%) <sup>a</sup>	38.9	61.10	5.800	NS
Moderate inf. (%) <sup>a</sup>	38.5	61.50	29.20	p<0.05
Light inf. (%) <sup>a</sup>	43.8	56.20	65.10	NS
Total (%)	42.0	58.00	32.10	p<0.05
<sup>b</sup> GMEC epg±SE	108±24	72±16	90±20	p<0.05

<sup>a</sup>Yates correction for 2 categories, df = 1. <sup>c</sup>WHO threshold for schistosomiasis is: Heavy infection = 500<sup>c</sup> epg; Moderate infection = 100-499 epg and Light infection ≤99 epg. <sup>b</sup>GMEC epg = Geometric Mean Egg Count (GMEC) expressed as epg per gram (epg) of stool, SE = Standard Error

Table 4: Prevalence of intestinal schistosomiasis in 972 school children in 18 schools classified by distance of the school from the lake shore

Distance (km)	No. of schools within distance	No. of pupils examined	No. of positive	Prevalence of infection (%)
<3	4	216	154	71.2
3-5	6	324	134	41.3
>5	8	432	24	5.5
Total	18	972	312	32.1

Table 5: Prevalence of intestinal schistosomiasis in 972 school children in 18 schools classified by distance of households from the lake shore

Distance (km)	Tested (%)	Light infections (%)	Moderate infections (%)	Heavy infections (%)	Total infections (%)
<3	25.2	28.2	9.8	2.9	40.8
3-5	20.1	32.8	16.4	4.6	53.8
>5	54.7	12.0	5.1	3.0	20.1
Total	100.0	20.3	8.5	3.3	32.1

Table 6: Prevalence of intestinal schistosomiasis in 972 school children before and after praziquantel and hygiene education intervention packages

Intervention package	Infected (%)			Change in infection (%)	Mean (%)	t-test
	Before	18 months after	Attrition (%)			
None (Control)	19.7	21.1	6.5	+1.4	20.4	p>0.05
Praziquantel (PZQ)	31.9	11.0	2.4	-20.9	21.5	p<0.05
Hygiene Educ (HYG)	26.5	14.1	2.4	-12.4	20.5	p<0.05
PZQ and HYG	29.3	6.0	2.5	-23.3	17.7	p<0.05

Table 7: Prevalence of *S. mansoni* among children from various households and self reported contact with Lake Victoria according to distance from the child's household to the shoreline

Contact	Number tasted (%)	Positive (%)	Number tested ( $\geq 5$ km)	Positive (%)	Total number tested	Positive (%)
None	117	15.4	373	2.9	490	7.1
Some	57	59.7	25	36.0	82	52.4
Frequent	153	90.2	247	38.9	400	58.5
Total	327	59.9	645	17.9	972	32.1
$\chi^2$ -test	p<0.05	-	p<0.05	-	p<0.05	-

The prevalence of infections in the schools was strongly correlated with the logarithm of the distance to the shoreline ( $R^2 = 0.89$ ;  $p<0.05$ ), meaning that proximity to contaminated water per se largely enhanced schistosomiasis infection.

Data on the prevalence of intestinal schistosomiasis as classified by the distance of the households from the lake among the 972 pupils drawn from 18 schools that were studied is shown in Table 5. It was shown that more than half (54.7%) of the pupils in the study area lived beyond 5 km from the shoreline and only 3.0% of these pupils within this distance had heavy infestations.

The prevalence of infection varied within a marginal range of 40.8, 53.8 and 20.1%, respectively for the three strata of households in the study area. The relationship between prevalence of infection with *S. mansoni* and distance from the household to the lake as determined by data from the three strata was not statistically significant ( $p>0.05$ ). This indicated that other than the lake, other contact sites played some role in schistosomiasis transmission in the study area.

**Intervention and re-infection studies:** Table 6 presents the results of the intervention study conducted using praziquantel treatment, taking the residents through on one hand and on the other hand using hygiene education and combined treatment with praziquantel and hygiene education in different study subjects both at school and at household level.

Praziquantel treatment decreased the prevalence of the infection by 20.9% as compared to education in hygiene which reduced the prevalence by 12.4%. The

highest reduction was recorded in subjects that were given hygiene education and treated with praziquantel.

The reduction in prevalence was statistically significant (t-test;  $p<0.05$ ). This meant that the combined effect of praziquantel treatment and hygiene education was better than when the two interventions were singly applied in control programmes.

**Results of the questionnaire outcomes:** Table 7 presents results of prevalence of *S. mansoni* among children from various households and self reported contact with Lake Victoria relative to the household's distance from the shoreline.

Pupils who reported to have had frequent contact with lake water had a prevalence of 58.5%; those who reported to have had occasional contact had a prevalence of 52.4% and those who reported to have had no contact during the last 1 year had a prevalence of 7.1% ( $p<0.05$  by  $\chi^2$ -test for trend). Similarly, the duration of contact with the lake was significantly ( $p<0.05$ ) associated with infection with *S. mansoni*.

It was concluded from the data that there existed some form of heterogeneity in the pattern of contact with snail infested water and the infection in the study area. This in effect meant that the distance from snail infested water bodies and the frequency of contact with such waters could be determinants of infections with schistosomiasis. Questions on self-reported contact with lake water and self-reported blood in the stool when included in the questionnaire determined if the responses would be helpful in detecting schistosomiasis-infected children in low prevalence areas. Of the 645 children who

Table 8: Odds Ratio (OR) and 95% Confidence Intervals (CI) for water related risk factors for infection with *S. mansoni* and exposure to snail breeding habitats

Contact sites and activities	Univariate OR (95% CI)	p-level	Multivariate OR (95% CI) <sup>b</sup>	p-level
<b>Lake victoria (Overall OR = 5.3; 95% CI = 4.1-8.6)</b>				
Swim	5.3 (3.8-7.4)	<0.001	1.70 (1.03-2.81)	0.037
Fish	4.1 (2.5-6.8)	<0.001	3.23 (1.70-6.15)	<0.001
Bathe	5.8 (4.1-8.1)	<0.001	NS	
Wash clothes	5.2 (3.7-7.1)	<0.001	2.07 (1.27-3.38)	0.004
Collect water	6.2 (4.2-8.7)	<0.001	NS	
<b>Ponds (Overall OR = 0.78; 95% CI = 0.43-0.91)</b>				
Swim	0.7 (0.5-1.0)	0.061	0.73 (0.49-1.10)	0.134
Fish	0.7 (0.4-1.4)	0.311	NS	
Bathe	0.9 (0.6-1.2)	0.336	NS	
Wash clothes	0.9 (0.7-1.3)	0.622	NS	
Collect water	0.7 (0.5-1.0)	0.047	NS	
<b>River Nzoia (Overall OR = 0.68; 95% CI = 0.34-0.74)</b>				
Swim	0.8 (0.6-1.1)	0.114	NS	
Fish	0.9 (0.5-1.4)	0.29	NS	
Bathe	0.6 (0.5-0.9)	0.004	NS	
Wash clothes	0.6 (0.4-0.8)	<0.001	NS	
Collect water	0.5 (0.3-0.6)	<0.001	NS	

<sup>b</sup>Multivariate model using general estimating equations controlling for age, sex and distance to Lake Victoria, NS = Not Significant

lived beyond 5 km from the shore, 42.2% reported some or frequent contact with lake water during the last 1 year while 38.6% of the children tested positive for infection (positive predictive value = 38.6%).

For those who lived beyond 5 km from the shoreline, the sensitivity and specificity of self-reported contact with Lake Victoria as a means of predicting *S. mansoni* infection were 90.5 and 68.4%, respectively. Among the 247 children who reported to have had frequent contact with Lake Victoria, 38.9% of them were infected (positive predictive value = 38.9%). However, the sensitivity of self-reported frequent contact with the lake was 82.7% indicating the likelihood of self reported contact with infested water bodies as a determinant in detecting schistosomiasis infections.

Presented in Table 8 is data on the Odds Ratio (OR) and 95% Confidence Intervals (CI) for water related risk factors for infection with *S. mansoni* and exposure to snail breeding habitats. Children infected with *S. mansoni* were more likely to have had contact with lake water during the previous 1 year (Odds Ratio (OR) = 5.3; 95% Confidence Interval (CI) = 4.1, 8.6) but less likely to have had contact with ponds (OR = 0.78; 95% CI = 0.43, 0.91) or rivers (OR = 0.68; 95%, CI = 0.34, 0.74). The prevalence of *S. mansoni* infection was significantly ( $p < 0.05$ ) associated with self-reported contact with Lake Victoria. Thus, self-reported contact with the lake proved to be a useful indicator of infection with intestinal schistosomiasis in this study. Swimming, fishing, bathing, washing clothes and collecting water from Lake Victoria were also all associated with a higher risk of infection while collecting water from ponds or rivers as well as bathing or washing

clothes in rivers was associated with a lower risk of infection. Also presented in Table 8 are results of multivariate logistic regression, controlling for age, sex, school and distance to the lake. The data presented indicated that children who reported to have had contact with the lake over the previous 1 year had a 6.8-7.8 times higher odds of being infected than those who did not have contact with the lake but had contact with ponds and the river, respectively. The specific activities associated with infection were swimming, fishing and fetching water from Lake Victoria. Swimming in ponds was also associated with a lower risk of infection ( $p = 0.134$ ).

## DISCUSSION

The wide range of prevalence of the infection among schools in the study area illustrated the focal distribution of the infection that was characteristic of schistosomiasis in any given endemic site. But the marginal differences observed implied that prevalence rates would continue rising if the disease was left unchecked and the composite human populations ought to be involved at all times.

It was apparent from the observed low to moderate prevalence of *S. mansoni* infection that the ponds and the other temporary water pools that were left behind after the flood waters receded did not seem to substantially play any significant role in *S. mansoni* disease transmission in Budalangi. The very low prevalence observed in schools situated far away from the lake was typical of transmission types that had been reported earlier in the Lake Victoria region (Kinoti, 1971) and in Bunyala and Samia locations (Masaba, 1978, 1983).

The present study found an increasing trend of the infection among children <5 years to 11 years with a peak prevalence of Schistosome infections in the 11-14 years age group which thereafter declined. Various investigators reported similar findings where the age-prevalence typically peaked in early adolescence (Loum, 1974; Pugh, 1979; Masaba, 1983; Fulford *et al.*, 1998). In addition, children aged 14 years or more were less likely to report playing or swimming in water. This was supported by the fact that children who were aged 14 years and above incurred reduced and declining infection rates with increasing age. Studies conducted elsewhere reported similar findings. For example in a survival analysis during a school-based treatment programme throughout a 9 years schistosomiasis study at the Kenyan coast by Satayathum *et al.* (2006), schistosomiasis infection was lower in older children. Similar results were reported in a survey in Dar-es-Salaam, Tanzania by Ndyomugenyi and Minjas (2001).

Other studies have reported age-acquired immunity to re-infection to have been a major contributory factor to the declining trend in prevalence among children aged 15 years and above (Etard *et al.*, 1995). However, it could not be concluded from the present study whether age-acquired immunity contributed to the decline in infection rates in children aged 14 years and above since, there was no negative association between *Schistosoma* ova load and age in the studies that focused on the intensity of the infection.

Although, the overall intensity of the infection was low and peaked at the 11-14 years age group this was also the age group that contributed almost half of the potential contamination (IPC = 49.5%) and therefore transmission of ova of the parasite. The finding conformed to observations documented by Schutte *et al.* (1981) and King *et al.* (1982) in which they found a linear relationship between the two parameters.

However, the findings reported in this study were in contrast with Bradley and McCullough (1973)'s and Abdel-Salam and Abdel-Fatah (1977)'s findings. Apparently, no conclusion could be drawn from the current observed differences due to the moderate prevalence and low intensity observed.

The overall intensity of the infection was much lower than the values obtained in Taita district at the Kenyan coast by Shimada *et al.* (1984). It was therefore possible that relatively fewer individuals in Budalangi could have developed severe disease from *S. mansoni* infection in comparison with those from other areas that were characterized by high intensity and prevalence.

The low association between male gender and *S. mansoni* observed in this study was in slight contrast with the findings from other similar studies conducted elsewhere. For example studies by El-Gendy *et al.* (1999) in Egypt, Satayathum *et al.* (2006) at the Kenyan coast and more recently by Rudge *et al.* (2008) in Zanzibar documented that males were the most infected in comparison to the females was complete opposite of the observations recorded in this study largely because females invariably made contact with water diurnally. The intensity of the infection was found to be higher in the males than in the females. Similar results were reported by Dalton and Pole (1978) who attributed this to the females' lower mean duration of contact with infested waters.

However this could not explain the situation in Budalangi since the prevalence trend was reversed where fewer males were infected but heavily so more than the females. This could be explained by the fact that the males started making contact with infected water later in life than did the female counterparts but later on they made lifelong contacts, especially if they dropped out of school to become fishermen.

The positive predictive value of self-reported blood in stool was low and could have been attributed to several reasons. First, the study was limited since only one stool specimen was collected at any one sampling instance. Studies have shown that repeated examination of stool specimens over consecutive days improved egg detection (Lengeler *et al.*, 2002). It was possible to have had an infected child reporting blood in stool with no ova of *Schistosoma* being detected in his stool if only one stool sample was used.

In addition this could have been exacerbated by the fact that the study population had low infection intensity where only 1.8% of the cases were detected as heavy infections (>500 GMEC epg). The results probably could have been different if reported blood in stool was compared to Circulating Anodic Antigen (CAA) from *S. mansoni* (Jordan *et al.*, 1993).

Secondly, children that either reported passing blood in their stool or tested positive for *S. mansoni* infection were referred for treatment to the local health facilities by an NGO, ICS in its continuous health surveys in the study area. Therefore self reported blood in stool could not be related to intense *S. mansoni* infection in the study area and there was a possibility that most of the observed cases of blood in stool may have been due to causes other than from *S. mansoni*.

School proximity to an open water source showed a very strong association with infection. Overall, one in three children who had intestinal schistosomiasis was likely to be found in children living near the shorelines of Lake Victoria. The clustering of *S. mansoni* infections near Lake Victoria and the epidemiologic data associating frequency of water contact with *S. mansoni* infection indicated that the lake could be the sole or primary source of infection.

The proximity to water sources had been consistently shown to be associated with schistosomiasis infection by Brooker *et al.* (2001), Handzel *et al.* (2003), Phillips-Howard *et al.* (2003) and Rudge *et al.* (2008). The strict relationship between *S. mansoni* prevalence and proximity to the lakeshore observed in this study was not peculiar in view of similar findings reported elsewhere around the lake region of Tanzania by Lwambo *et al.* (1999).

The schools that had prevalence rates greater than 50% in the present study were located within 2 km from the lake. In Lwambo *et al.* (1999) studies, the school prevalence rates ranging from 0-65% were reported and all the schools that had prevalence greater than 20% were located within 5 km from Lake Victoria. Brooker *et al.* (2001) in their studies also found a strong inverse association between distance to Lake Victoria and the

prevalence of *S. mansoni*. They came up with a 5 km cutoff being the point for correctly predicting schools of high prevalence ( $\geq 50\%$ ).

However, the above cutoff distance was less useful in predicting schools which had moderate levels of infection (20-50%). These results suggested that the distance from the shore would be a useful indicator of the prevalence although, the specific distance from the shore that would trigger mass treatment would probably vary with the exact location. In contrast to the foregoing other studies reported no association or variable influence of proximity to the lake on schistosomiasis infection (Lima e Costa *et al.*, 1991; Kloos *et al.*, 1998).

### CONCLUSION

The transmission of human intestinal schistosomiasis in the Budalangi endemic focus was stable but at a low to moderate rate and was largely influenced by the pattern of the dynamics of the vector snail population. The overall prevalence and intensity of infection in the study population and that obtained after re evaluation one and a half years post intervention with different packages confirmed the value of the school-based approach for adoption by the proposed control programme. However, *S. mansoni* infection was found to be localized and focal in nature in Bunyala district.

The study showed that children in Bunyala district were lightly to moderately infected and that there was an association between the level of infection and the intensity of infection. The distance to Lake Victoria was the most significant predictor of infection for *S. mansoni* among school children in the endemic focus.

Questions regarding water-related behaviors or time spent in the lake were found to be useful in identifying infected children who resided beyond the cut off point from L. Victoria to area-wide distance for mass treatment. The lesson learnt was that the questions must be carefully structured to maximize both the sensitivity and specificity of the responses. Swimming, fishing and fetching water from the lake were the most significant risk factors for the infection. The heterogeneous distribution of intestinal schistosomiasis infections in the Budalangi endemic focus had important implications for potential mass treatment programs. Within 3 and 3-5 km of the shoreline, the school prevalence averaged 40.8 and 53.8%, respectively. Based on the WHO guidelines (Montresor, 1998) all persons living in these villages, regardless of age would be treated for schistosomiasis. From 5 km away from the shoreline, the prevalence remained  $>20$  but  $<50\%$ . Accordingly, selective treatment

of school-aged children in these villages would be recommended. As the distance increased further up to over 10 km mark, the prevalence became considerably lower and treatment of these households therefore would be based on a clinical or laboratory diagnosis of the infection.

Based on the findings of the present study it was shown that all school-aged children in Bunyala district could be treated for schistosomiasis especially those living within a specified distance off a known source of transmission of schistosomiasis. In this case school children living within 5 km from Lake Victoria needed to be treated with praziquantel. If a school-based mass treatment program were to be undertaken for all schools located within 5 km of Lake Victoria, 10 schools would receive treatment of schistosomiasis with a sensitivity of 100%. The 8 schools having prevalence  $<20\%$  would be categorized as receiving no treatment. At an individual level, such a programme would effectively treat 540 (55.5%) of 972 school children in the study area, 288 (92.3%) of 312 children infected with intestinal schistosomiasis and 100% of the children with heavy infections. Thus, by selecting schools based on proximity to Lake Victoria, a control programme would provide praziquantel to only a half of all the children in the study area yet effectively treat more than nine-tenths of those infected with schistosomiasis. Accordingly therefore, all children who tested positive for schistosomiasis were treated with praziquantel ( $40 \text{ mg kg}^{-1}$ ) and children who tested to be positive for roundworms, whipworms or hookworms were treated with albendazole (400 mg). But since schistosomiasis transmission tended to be focal in nature as has been seen from the foregoing, localized snail control could be undertaken to complement chemotherapy in reducing the transmission.

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