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PREVALENCE AND INTENSITY OF SINGLE AND MIXED *SCHISTOSOMA MANSONI* AND S*CHISTOSOMA HAEMATOBIUM* INFECTIONS IN PRIMARY SCHOOL CHILDREN IN RACHUONYO NORTH DISTRICT, HOMABAY COUNTY, WESTERN KENYA
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ABSTRACT

***Objective*: To determine the prevalence and intensity of single and mixed schistosomiasis infection among primary school children in Rachuonyo North District, Homabay County in western Kenya.**
***Design*: A descriptive cross sectional study.**
***Setting*: A parasitological survey involving six primary schools in Rachuonyo North District, Homabay County.**
***Subjects*: Four hundred and seventy four(474) school children, seven to 15 years old. Each child provided a urine and stool sample for diagnosis of schistosome and soil-transmitted helminth infections. Urine samples were processed using the filtration technique and the sample examined by microscopy for *Schistosoma haematobium* ova. Stool samples were processed by the Kato-Katz technique and the sample examined by microscopy for ova of *S. mansoni* and soil-transmitted helminths.**
***Results*: Prevelance of *S.haematobium* was 37.6%, *S.mansoni* (12.2%), hookworm (14.6%), *Ascaris lumbricoides* (6.3%), *Trichuris trichiura* (5.3%) among the children in the participating schools. Overall, 78.6% of the children infected with *S.haematobium* had light infection (< 50eggs per 10 ml of urine) and the rest (21.4%) had heavy infection (≥50 eggs per 10 ml of urine). On the hand, 75.9% of those with *S.mansoni* had light infection (one to 99 eggs per gram of stool (EPG), and the rest (24.1%) had moderate infection intensities (100-399 (EPG).**
***Conclusion*: This is the first report in which both *S.haematobium* and *S.mansoni* are found together in the same geographic locality in high prevalence in the Lake Victoria region of western Kenya, with *S. haematobium* being the most predominant in some places. Rachuonyo North District becomes a new focus of mixed human schistosome infections in Kenya. The significant burden of schistosomiasis in this area highlights the need to include regular treatment for schistosomiasis in the national school based deworming programme especially now that the infection occurs in areas more than five kilometres away from the lake.**

INTRODUCTION

Schistosomiasis continues to attract an increasing interest among health researchers, policy makers and donor agencies due to their impact on subtle and severe morbidity in endemic regions. It is estimated that worldwide 500–600 million people are at risk of infection out of which an estimated 207 million people worldwide are infected with the disease (1), with a bulk of the cases (90%) residing in sub-Saharan Africa (2,3). In Kenya current estimates show that more than 9.1 million people are infected with either one or both species of schistosomiasis (4). A large proportion (70%) of those at risk of infection with schistosomiasis is estimated to be school going children aged between five to 14 years (5). Three major endemic areas for the disease in Kenya are Lake Victoria basin, Coast and some parts of Lower Eastern (Kitui county) (6). In the Lake Victoria basin schistomiasis is predominantly caused by *S. mansoni* (7, 8) and previous studies indicate that there is a direct relationship between the prevalence of *S. mansoni* and distance from Lake Victoria (5). On the coast of Kenya, schistosomiasis is predominantly caused by *S. haematobium* (6). Mixed infections of *S. haematobium* and *S. mansoni* have been reported in Taveta in Coast Province and some parts of lower Eastern Province (Kitui county) (6). However data regarding the prevalence of mixed schistosome infection (*S.haematobium* and *S.mansoni*) in the lake region are remarkably lacking.

Mixed infections of *S.haematobium* and *S.mansoni* have an impact on morbidity and overall health. Children with mixed schistosome infections, especially those with heavy infection intensities, tend to experience more severe cognitive outcomes and other health problems, such as liver and bladder morbidity, than children with only one schistosome infection (9). Such children are also known to have poorer academic scores compared with children with a single infection (10).

Despite the availability of effective and safe drugs for their treatment schistosome infections continue to exert significant morbidity in sub tropical countries. Among the morbidities are under-nutrition, anaemia and cognitive impairment (11, 12), with school children harbouring the heaviest burden of disease (5). The degree of morbidity is related to the intensity of infection and the number of different species harboured (9). There is therefore a great need for more up to date information on the extent of disease burden and communities at risk of schistosomiasis in western Kenya.

The objective of this cross-sectional study was to determine the prevalence and intensity of *S. haematobium* and *S. mansoni* infections among primary school children in Rachuonyo North District, Homabay County in western Kenya. Currently, there is a paucity of data on prevalence of mixed *S.haematobium* and *S.mansoni* infection in Kenya and the only areas where mixed *S.haematobium* and *S.mansoni* infection has been reported is in Taveta and some parts of lower Eastern (Kitui county) (6).

MATERIALS AND METHODS

Study Area: The Study was conducted in Rachuonyo North District, Homa Bay County which borders Lake Victoria in western Kenya. Rachuonyo North District has a population estimated at 153,000 and a land area of 473 km^2 (13). The district lies between latitude 0026` to18`north and longitude 33058`east and 34033`west. The region's topography varies and is characterised by hilly areas in the northern and western side and a gentle slope towards Lake Victoria. A majority of those residing down the slope towards Lake Victoria rely on the lake water which is the primary source of *S.mansoni* infection, with an inverse association between distance to the lake and prevalence of infection (8) while a majority of the people residing on the hilly areas rely on unprotected dams, wells and springs which are the primary sources of *S.haematobuim* infection (14) This was a descriptive cross-sectional study in which 6 primary schools were randomly selected from a list of primary schools in Rachuonyo North District obtained from the District Education Officer (DEO). A total of 474 children in the six primary schools were further randomly selected using the random number tables developed from excel soft ware and the number of children sampled was based on the sample allocated per school based on Probability Proportional to Size allocation (PPS). Informed consent was obtained from parent or guardian, and assent was obtained from the student prior to enrolment into the study, participation was voluntary and hence, children could withdraw at any time without further obligations and without losing any benefit of the study.Children infected with schistosomiasis were treated with 40 mg/kg praziquatel (PZQ) and those infected with soil-transmitted helminthes (STH) were treated with 400 mg albendazole (ALB) .This study was reviewed and approved by the Scientific and Ethical Review Committees of the Kenya Medical Research Institute (KEMRI) and referenced as SSC Protocol No. 2378.

Parasitological examination:Parasitological examination was based on one stool (double slide) and urine sample (two filters) per child. Each study child was provided with a plastic container for a stool sample and plastic cup for urine on the morning of the day of survey, and instructed to bring the samples. 95.6% and 97% of children returned stool and urine samples respectively, and these were transported to the Ministry of Health's Division of Vector-Borne and Neglected Tropical Diseases (DVBD) laboratory, Homabay, where they were processed. Hookworm eggs were examined within 1 hr of slide preparation whereas all other helminths were examined within three hrs. Each stool sample was prepared in duplicate on a glass microscope slide using the Kato-Katz method and the sample examined by microscopy for eggs of *S. mansoni*, *A. lumbricoides, T. trichiura* and hookworm (15). A template which holds approximately 41.7 mg of faeces was used to prepare the stool samples, and parasite egg density was expressed as number of eggs per gram (EPG) of faeces.

Urine samples were examined for eggs of *S. haematobium,* approximately 10 ml of urine collected between 10:00 am and 2:00 pm from a study child was filtered through a 13 mm polycarbornate nuclear pore filter (Nuclear pore R, Costar Europe

Ltd., Badhoevedorp, the Netherlands) mounted on a filtration apparatus (16). Each urine sample was prepared in duplicates of 10 ml aliquots of urine each. The filter was then placed on a labeled slide and examined under a microscope within six hrs. The average egg count on the duplicate filters were recorded, and the concentration of parasite eggs expressed as number of eggs per 10 ml urine. Intensity of infection was categorized according to the World Health Organization (WHO)-proposed thresholds (17).

Statistical analyses: The data obtained were entered in Microsoft Excel spread sheets, then cross checked and transferred to SPSS for windows version 20 (SPSS; Atlanta GA, USA) for analysis. Data were tested for normality prior to analysis, and where necessary log-transformed to achieve normality. Arithmetic means of egg counts were calculated and expressed as eggs per gram (epg) for *S.mansoni* and eggs per 10 ml urine for *S.haematobium*. Descriptive statistics were carried out to determine relative frequencies, percentages and averages of variables. Associations between infection intensities and prevalences were determined using Pearson's correlation (r). P values < 0.05 were considered statistically significant.

RESULTS

Demographic data of study children: The mean age of the 474 school children from the six study schools was 10.88 (age range, 7-15 years) and the median was 11 years. Of these 474 children, 250 (52.7%) were males and 224 (47.3%) were females (see Table 1). Majority of the children enrolled in the study were between nine to 14 years old.

Table 1
Distribution of the study population age group by sex

	Frequency					
Age group	Female	%	Male	%	Total	%
≤ 8 years	27	50	27	50	54	11.4
9-11 years	107	45.5	128	54.5	235	49.4
12-14years	88	49.2	91	50.8	179	37.8
≥ 15 years	2	33.3	4	66.7	6	1.3
Total	224	47.3	250	52.7	474	100

Prevalence of schistosomiasis and the soil-transmitted helminth infections: The prevalence of *Schistosoma haematobium* was 37.6%, *S. mansoni* (12.2%), hookworm (14.6%), *Ascaris lumbricoides* (6.3%), and *Trichiuris trichiura* (5.3%) (see Table 2). Interestingly, both *S. haematobium* and *S. mansoni* were present in the study locality but *S. haematobium* was the most predominant parasite. Overall, *S. haematobium* was the most common parasite followed by hookworm.

Table 2
Overall prevalence of schistosomiasis and the soil-transmitted helminth infections

Examination	**Worm infestation in all schools**				
	S.haematobium	***S.mansoni***	**Hook worm**	***A.lumbricoides***	***T. trichura***
No. examined	474	474	474	474	474
Prevalence (%)	178/474(37.6%)	58/474(12.2%)	69/474(14.6%)	30/474(6.3%)	25/474(5.3%)

Parasite prevalence by schools: Both *S. haematobium* and *S. mansoni* were present in the area. Prevalence of *S.haematobium* infection differed significantly between the six study primary schools, ($p<0.001$, $\chi2 = 130.774$, df=5) as shown in Table 3. The highest prevalence rate was observed in Wimagak primary school (65.9%), Omuga (55.3%), Oriang manyuanda 53.8%, Wikondiek 44.6%, Yawo kamolo 10.7% and Kendu muslim 0%. *S.mansoni* infection was significantly different in all the six primary schools ($p<0.001$, $\chi2 = 89.060$, df=5). The highest prevalence rate was observed in Oriang manyuanda (Table 3). Overall, however, *S. haematobium* seemed to be the most predominat schistosome species in the study area. Also, present in the area were soil-transmitted helminth (STH) parasites, namely, hookworm, *Ascaris lumbricoides* and *Trichuris trichiura.* Hookworm was the most common STH.

Table 3
Parasite prevalence by schools

School	Worm infestation examination				
	S. haematobium	*S.mansoni*	Hook worm	*A.lumbricoides*	*T.trichura*
Wimagak					
Number examined	91	91	91	91	91
Prevalence (%)	60/91(65.9%)	0/91(0%)	23/91(25.3%)	5/91(5.5%)	1/91(1.1%)
Oriang manyuanda					
Number examined	78	78	78	78	78
Prevalence (%)	42/78(53.8%)	25/78(32.1%)	8/78(10.3%)	4/78(5.1%)	4/78(5.1%)
Kendu muslim					
Number examined	89	89	89	89	89
Prevalence (%)	0/89(0%)	27/89(30.3%)I	8/89(9%)	2/89(2.2%)	1/89(1.1%)
Wikondiek					
Number examined	56	56	56	56	56
Prevalence (%)	25/56(44.6%)	5/56(8.9%)	8/56(14.3%)	3/56(5.4%)	6/56(10.7%)
Yawo kamollo					
Number examined	84	84	84	84	84
Prevalence (%)	9/84(10.7%)	0/84(0%)	7/84(8.3%)	5/84(6%)	3/84(3.6%)
Omuga					
Number examined	76	76	76	76	76
Prevalence (%)					
	42/76(55.3%)	0/76(0%)	15/76(19.7%)	11/76(14.5%)	10/76(13.2%)

S.haematobium and S.mansoni prevalence by age group: There was a significant association between age group and *S.haematobium* prevalence: $p<0.005$ ($\chi 2 = 10.364$, df=3). Prevalence in age group below eight years was 33.3% building up to 44.7% in age group 9-11 years and gradually falling in the older age groups 12-14 years (29.6%) and above 15 years (16.67%). There was a significant association between age group and *S.mansoni* prevalence: $p<0.01$ ($\chi 2 = 16.233$, df=3). Prevalence was highest in age group below eight years (18.51%), followed by age group ine to 11 years (12.76%) then gradually fell in the older age groups 12-14 years (10.61%) and above 15 years (0%) (Table 4).

Table 4
S.haematobium and S.mansoni prevalence by age group

Age group		*S.haematobium*	*S.mansoni*		
	N	Number positive	Prevalence (%)	Number positive	Prevalence (%)
≤ 8 years	54	18	33.3%	9	18.51%
9-11 years	235	105	44.7%	30	12.76%
12-14years	179	53	29.6%	19	10.61%
≥ 15 years	6	1	16.67%	0	0%

Mixed infection of S.haematobium and S.mansoni in the study population: Among the 474 study subjects 11 (2.3%) were infected with both *S.haematobium* and *S. mansoni.*

Mixed infection of S.haematobium and S.mansoni per school: Two schools had mixed infections (*S.haematobium* and *S.mansoni*) occurring in the same geographic locality and further 11 children out of the 134 in these two schools were infected with both *S.haematobium* and *S.mansoni*. Mixed infection of *S.haematobium* and *S.mansoni* was significantly different in the two primary schools which had cases of mixed infections ($p<0.001$; $x^2 = 180.419$; df = 1). (Table 5)

Table 5
Prevalence of mixed infection of S.haematobium and S.mansoni by school

School	Mixed infection of *S.haematobium* and *S.mansoni*
Oriang manyuanda	
Number examined	78
Prevalence of mixed infection (%)	10/78(12.8%)
Wikondiek	
Number examined	56
Prevalence of mixed infection (%)	1/56(1.8%)

Intensity threshold
Classification of intensity of schistosomiasis among the study subjects: Majority of *S. mansoni* (75.8%) cases were categorised as light in intensity, and the rest as being moderate in intensity. Similarly, majority of *S. haematobium* infections (78.6%) were categorised being light in intensity (see Table 6).Level of intensity set by WHO threshold for light, moderate and heavy infections with *Ascaris lumbricoides*, T*richuris trichiura*, Hookworm and *schistosomes* (17).

Table 6
Classification of intensity of schistosomiasis

Level of infection intensity	Frequency	Percentage
S.mansoni (eggs per gram of stool)	N=58	
Light (1-99)	44	75.86
Moderate (100-399)	14	24.13
Heavy (≥400)	0	0
S.haematobium (eggs per 10 ml of urine)	N=178	
Light (< 50)	140	78.57
Heavy (≥50)	38	21.43

Association between S. haematobium prevalence and S. haematobium intensity: A scatter plot was generated between *S. haematobium* prevalence and *S. haematobium* intensity by age group giving an R^2 of 0.9586. This was further analysed by correlation and a regression analysis.

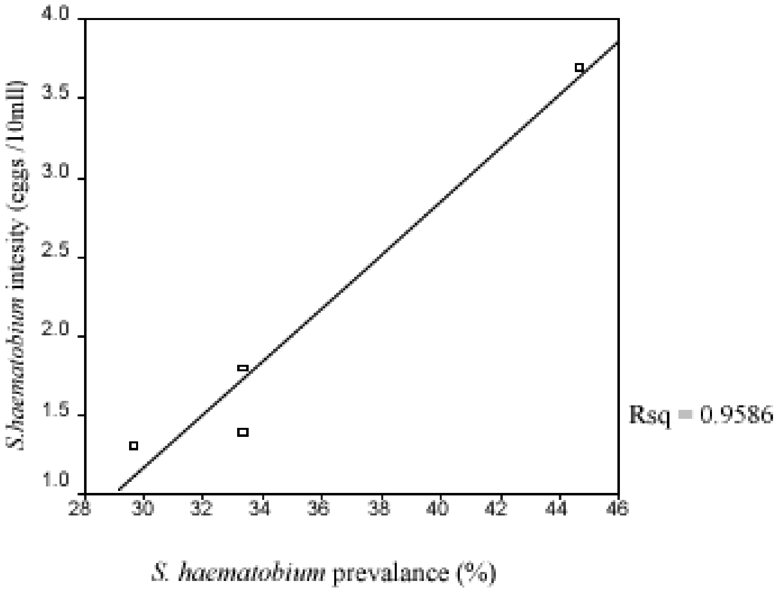
Correlation: Pearson correlation was 0.979 which was significant at $p< 0.05$ (p=0.021).

Regression analysis: F value (ANOVA) was equal to 46.289, $p<0.05$ (p=0.021).

t-test value: t-test value generated from the regression analysis was equal to 6.804, $p< 0.05$ (p=0.021). This indicates a significant association between *S. haematobium* prevalence and *S. haematobium* intensity. (Figure 1)

Figure 1

A scatter plot showing association between S. haematobium prevalence and S. haematobium intensity



Association between S. mansoni prevalence and S. mansoni intensity mansoni: A scatter plot was generated between *S. mansoni* prevalence and *S. mansoni* intensity by age group giving an R^2 of 0.9956. This was further analysed by correlation and a regression analysis.

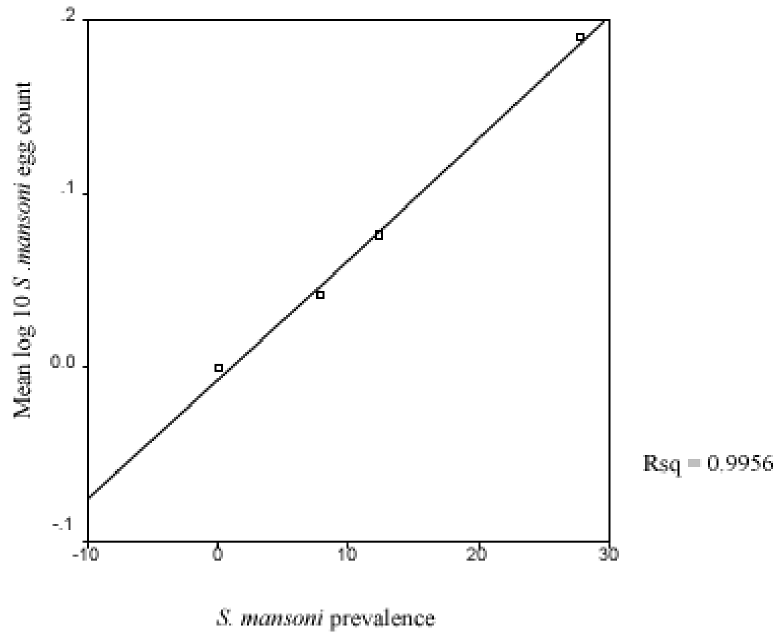
Correlation: Pearson correlation was 0.998 which was significant at p< 0.05 (p=0.002).

Regression analysis. F value (ANOVA) was equal to 452, p<0.05 (p=0.002).

t-test value: t-test value generated from the regression analysis was equal to 21.277, p< 0.05 (p=0.02). This indicates a significant association between *S. mansoni* prevalence and *S. mansoni* intensity. (Figure 2).

Figure 2

A scatter plot showing relationship between S. mansoni prevalence and S. mansoni intensity



DISCUSSION

This cross-sectional study highlights the prevalence of single and mixed schistosome infections and STH infections and also outlines the intensity of schistomiasis among primary school children in Rachuonyo North District, Homabay County.

The mean school prevalence of *S. haematobium* in this study (37.6%) was slightly lower than that of a study in Kwale, Coast province Kenya (50%) (18). The mean school prevalence of *S. mansoni* in this study (12.2%) was lower compared previous studies from western Kenya (16.3% and 38.8%) (8, 19) but was higher compared to a study in Kampala, Uganda (4.1%) (20), Differences may be due to the focal distribution of *S. mansoni* (21) and close proximity of schools to lake Victoria (8). The wide range of schistosomiasis infection prevalence rates among schools in this study illustrates the focal distribution characteristic of schistosomiasis (21).

In contrast, the mean STH prevalence for schools in this study was lower compared to other studies in western Kenya (8,22) and on Pemba Island of Lake Victoria, Tanzania (23). For instance prevalence of hookworm infections observed in the current study (14.6 %) was much lower than what was reported in Tanzania (38%) (24) and Western Kenya (8) (42.5%). In this study Hookworm (14.6%) was the most predominant STH followed by *Ascaris Lumbricoides* (6.3%) then *Trichuris trichiura* (5.3%) this data supports previous observations that hookworm is the predominant STH infection within the Lake basin. (8,25). Two observations may explain the relatively low STH prevalence in this study, First, the direct smear microscopic analysis of single stool samples may have missed light infections because of poor sensitivity and day-to-day fluctuation in egg excretion (26). Future surveys may be enhanced by examining stool samples collected for at least two consecutive days or use of concentration techniques. Second, the low STH prevalence observed in this study may be attributable to the Kenya National deworming exercise conducted in 2012, in which most of the schools in this study participated.

Mixed infection of *S.haematobium* and *S.mansoni* was observed in this study. About 2.3% of children harboured both *S. mansoni* and *S.haematobium* infections. This is the first time mixed infection is being reported in western Kenya. This has put Rachuonyo North District in the map as a new area with mixed infection of *S.haematobium* and *S.mansoni* in Kenya after Taveta and some parts of Lower eastern (6).

Infection intensities were predominantly light for *S. haematobium* and *S.mansoni* supporting previous observations that most individuals in an endemic community excrete low numbers of eggs (27). However there were few cases of moderate infections and heavy infections. Increase in prevalence of schistosomiasis was associated with increase in intensity this observation has been supported by other studies (18,27). The prevalence of schistosomiasis and STH infections in this study has several implications for mass treatment programs. WHO recommends mass drug administration with Praziquantel (for schistosomes) and Albendazole or mebendazole for Soil Transmitted Helminthes(STH) wherever the prevalence of infection exceeds 10% and 20%, respectively (28). Following this recommendation, 6 (100%) of the schools in this study require mass treatment for schistosomiasis. Of the 474 school children surveyed, (100%) would benefit from mass treatment with Praziquantel. 3 schools (Schistosomiasis prevalence >50%, classified as high risk) and two schools (Schistosomiasis prevalence ≥20% but <50%, classified as moderate risk) would require treatment once a year and once every two years, respectively (28).

In this study, two (33.33%) of the schools (STH prevalence ≥20% but <50%, classified as low risk) would require mass treatment for Soil Transmitted Helminthes once each year (28). Of the 474 school children surveyed, 167 (35.23%) would benefit from mass treatment with Albendazole or mebendazole. Based on our findings, two schools would require co-administration of Praziquantel and Albendazole or mebendazole, and six schools would require Praziquantel. The absence of soil transmitted helminthes in several schools, absence of schools with >50% soil transmitted helminthes(STH) prevalence and the very low prevalence of moderate-heavy infection intensities perhaps reflect the impact of the 2012 National deworming exercise.

In conclusion findings from this study shows that there is mixed *S.haematobium* and *S.mansoni* infection in Rachuonyo North District, this has put the District on the map as a new area with mixed schistosomiasis infection after Taveta in the coast and some parts of Lower eastern (Kitui County). *S.haematobium* is more prevalent and with a higher intensity than *S.mansoni* in Rachuonyo North District. The significant burden of schistosomiasis and soil transmitted helminthes in these schools highlights the need for routine deworming programmes.

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