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Prevalence Of Single And Dual S. Mansoni And S. Haematobium Infections In Primary School Going Children, An Indicator Of Infection Status In The Community After Two Years Of Deworming In Taveta Sub County, Kenya

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Abstract: ***Background: Parasitic infections caused by schistosomes are among the most prevalent communicable diseases of humans who live in endemic parts of the developing world. This study sought to investigate the infection status of Schistosoma mansoni and Schistosoma haematobium in primary school going children in Taveta Sub County, Kenya where there is an on going nationwide mass drug administration control programme for primary school children.***

Methods: Stool and urine samples were examined using the Kato Katz Technique and filtration methods respectively. The sampling frame included 442 primary school children of both sexes in the county. The observed overall prevalence of both S. mansion and S. haematobium were calculated by gender and age groups. Confidence intervals of 95% (95% CI) were calculated by binomial logistic regression. Comparison of prevalence by gender and age groups were tested on significance of fisher's exact test. The significance of the factors associated with infection of S. mansoni and S. haematobium in the school children was determined using the multivariable logistic regression model reporting the odds ratio at 5% level significance and 95% confidence intervals. Factors for the infection were selected using forward step-wise variable selection method. Differences in proportions by age, sex and school were assessed by logistic regression, while differences in means were tested using the chi-square test and relationships between them were evaluated using the correlation co-efficient.

Results: The overall prevalence of S. mansoni was 11.8%, (95%CI 8.7%-14.6%) while that of S. haematobium was 24.3 %, (95%CI 20.4%- 28.4%) respectively. Further analysis revealed that out of the 442 primary school children 24 had dual infection (both S. mansoni and S. haematobium).

Conclusions: The prevalence of infection in Taveta Sub County is worth noting. Even after the annual National government deworming program for primary school children, there are still significant levels of infection. In addition some of the pupils have dual infections with S. mansoni and S.haematobium indicating double morbidity.

Infection with schistosomiasis is a vicious cycle that does not discriminate; therefore it is highly likely that the adult community is also infected.

Keywords: S. mansoni, S. haematobium, Prevalence, Dual infection

I. INTRODUCTION

Schistosome and soil-transmitted helminth infections are among the most common infections in developing countries [1]. The parasites that cause schistosomiasis have freshwater snails as their intermediate hosts. The infectious form of the parasite, known as cercariae, emerges from the snail, hence contaminating water. Infection occurs when human skin comes in contact with contaminated freshwater infested with cercariae [2]. Most human infections with schistosomes are

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caused by three species of Schistosomes; *S. mansoni*, *S. haematobium*, or *Schistosoma japonicum*. In Sub Saharan Africa freshwater bodies colonized by intermediate host snails of the genera Biomphalaria and Bulinus are responsible for infection with *S. mansoni* and *S. haematobium* respectively.

Schistosomiasis is most prevalent in poor communities that lack access to safe drinking water and adequate sanitation occurring within the tropical and sub-tropical areas of the world. It is estimated that Schistosomiasis affects almost 240 million people worldwide, while more than 700 million people live in endemic areas [3]**.** A review of disease burden by the World Health Organization estimated that more than 200,000 deaths per year occur due to schistosomiasis in sub-Saharan Africa [3]**.** Schistosomiasis is more endemic in communities where poverty, poor nutrition, inadequate sanitation and minimal health care prevail. Schistosomiasis can infect and affect all members of a population but the most susceptible group and the highest rate of infections are often seen in children between the ages of 5 and 15 years. It has been demonstrated that chronic schistosomiasis reduces the capacity of those infected to work and in some cases can result in death. In children schistosomiasis can cause anaemia, permanent organ damage, stunting, impaired cognitive function, and a reduced ability to learn [1]**.**

In Kenya it is estimated that six million people are infected with either urinary or intestinal schistosomiasis [4]**.** Schistosoma infection has been endemic in some regions, especially in areas with water irrigation projects, which provide a habitat for the snail vector to thrive. In Mwea region schistosomiasis transmission was recorded soon after the irrigation scheme was initiated in the 1950s. This area borders Machakos, another endemic area in central Kenya where irrigation is not practiced. However no comparative studies on impact of irrigation on the transmission of the disease have been carried out in Kenya [5]**.** In the endemic region of Taveta a study by [6] indicates that prevalence of schistosomiasis was high in Kenya's post independence period. These workers showed that out of a total of 963 individuals examined for stool and urine in three villages in Taveta, 69.6% were infected with either *S. mansoni* (23.6%) or *S. haematobium* (28.6%), while 14.7% were co-infected with both. A more recent survey conducted among 470 primary school children in the same region revealed 44% infection rate by either *S. mansoni*, *S. haematobium* or with both species [7]**,** perhaps indicating that there had been minimal change in the infection status during the intervening period.

II. METHODS

STUDY AREA

This study was conducted in Taveta Sub County. Taveta Sub County is located in Taita Taveta County in the Coastal region of Kenya. It covers an area of 17,084.1 sq Km. The county experiences mean annual rainfall of 650 mm per annum with temperatures averaging 23ºC. It has water resources such as Lake Chala, Lake Jipe and Mzima springs that supply the coastal region with water (www.maplandia.com). The site was selected because of the unique prevalence of both *S.mansoni* and *S.haematobium* infection, among the population especially in the primary school children [7]**.**

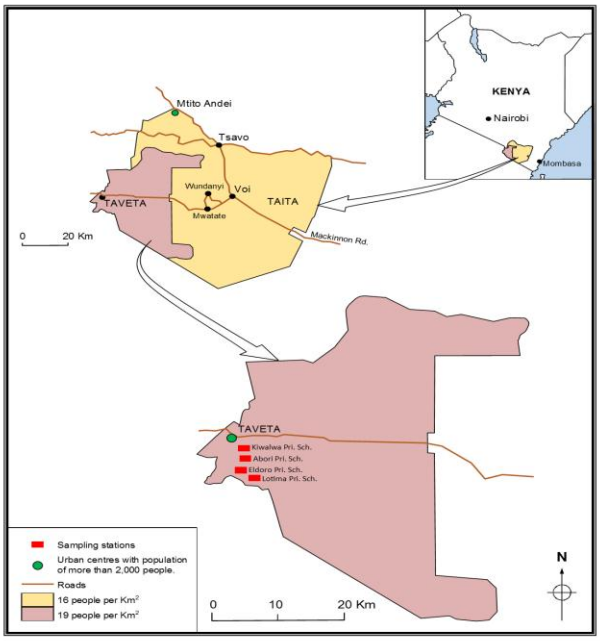

Figure 1: Map of the study area (Source, goggle maps Kenya; 2014)

STUDY POPULATION

The study population was 442 primary school children aged 5-16 years, from four primary schools namely, Lotima, Kiwalwa, Abori and Eldoro. The Sub County was purposively sampled owing to the endemicity of helminthic infections.

STUDY DESIGN

Selected schools were visited 3 months prior to the survey date in order to have the purpose of the survey explained to the head teacher and class teachers concerned. Two levels of consent were sought, according to the sample population. School-level consent was sought from county officer in charge of education and thereafter from the School's headmaster. Since the national deworming is an ongoing programme, the parents and guardians were already aware of the planned activities as Information had therefore already been provided. They were called for a meeting where they were given the chance to ask questions. They were further assured that participation of their children in the study was completely voluntary, and that they had the right to withdraw their children from the study at any time, should they wish to do so.

Four primary schools in Taveta Sub County were selected to participate in the study by random sampling. Pupils from class 1-6 were selected from both sexes using computer generated numbers in a process where each child stood a chance of being selected. For each school, the selection exercise for children took place in the morning while the pupils were in the assembly.

The selected children were put in a separate class rooms as the rest of the pupils were released to go to their respective classes to continue with their normal class schedule and lessons. Randomly selected children who declined to take part in the study were not subjected to any duress, but were instead automatically replaced.

III. SAMPLE COLLECTION

Stool and urine samples were collected from selected pupils at mid morning and in the respective schools. Girls collected their samples from the girl's toilets while boys collected their samples from the boy's toilets.

COLLECTION OF STOOL SPECIMEN FOR *S. MANSONI*

On the day of enrolment to the study, each selected pupil was given a labelled container with a tight- fitting lid (Poly Pot) and instructed to place a portion of his or her own stool sample inside. Specimens were collected separately by boys and girls in their respective toilet facilities within the school.

The sample was then labelled with the child ID awaiting processing in the laboratory.

STOOL PROCESSING AND EXAMINATION FOR *S. MANSONI*

Screening of infection for both soil transmitted helminthes and schistosome was based on a double slide 47.1mg Kato-Katz smears [8] prepared from fresh stool samples. The stool specimens were sieved by straining through nylon mesh and the smooth material scraped off the opposite side using plastic spatulas. They were then applied to microscope slides through a plastic template with a cylindrical hole that delivered 47.1 mg. The cylindrical blob of faecal material was covered with a cellophane strip that had been pre-soaked in a solution of malachite green and glycerol. The preparation was inverted on a flat absorbent surface and pressed gently to make a circular smear. Prepared slides were left to clear for a minimum of 45 minutes before examination under low power of a compound microscope

The thick Kato smear was systematically observed with the help of experienced technicians. The positive and negative slides were noted and the number of eggs expressed as eggs/gm of feaces (epg) for each of the positive slides recorded on data sheets for later analysis. Quality control was ensured through systematic random re-examination of 10% of the slides examined each day by an experienced technician.

URINE COLLECTION PROCESSING AND EXAMINATION FOR *S. HAEMATOBIUM*

Each selected pupil was also given another container to place a morning urine sample in. The Urine was then labelled using the child ID

Each child was expected to bring a mid-morning urine sample, which was graded visually for presence of gross hematuria (visible blood in urine)on a scale of 1—6; 1 represented normal urine and 6 represented dark red blood in urine, with a grading of 4—6 indicating gross hematuria. Urine was then tested using the filtration method, whereby 10ml of urine was drawn into a disposable syringe with an extension tube from the urine container. The urine was forced through a 25mm filter with 20um pore mounted on a filter holder (Nucleopore Corporation CA 94566).

The filters were then observed under x40 magnification for *S. haematobium* eggs. Prior to observation under a microscope, the filter was moisturized with a drop of normal saline to render the eggs visible

ETHICAL CONSIDERATIONS

Ethical clearance for this study was sought from KEMRI's Scientific Steering Committee (SSC) and Ethical Review Committee (ERC) prior to commencement of activities.

IV. DATA MANAGEMENT AND ANALYSIS

DATA COLLECTION, ENTRY AND STORAGE

The baseline data on sex, age, prevalence and intensity was collected from 442 school children in 4 primary schools located in Taveta Sub County. Data was collected on paper form, counter-checked for accuracy, and verified before double entry into a computer Excel 2007 spreadsheet. All statistical analysis was survey set and carried out using STATA version 12.0. Identity numbers instead of names were used for confidentiality.

DATA ANALYSIS

The observed overall prevalence of both *S. mansoni* and *S. haematobium* were calculated by sex and age groups. Confidence intervals of 95% (95% CI) were calculated by binomial logistic regression. Comparison of prevalence by sex and age groups were tested for significance using the Fisher's exact test. This analysis used the following age groups: 5-7, 8-10, 11-13 and >13 years old. The significance of the factors associated with infection of *S. mansoni* and *S. haematobium* in the school children was determined using the multivariable logistic regression model reporting the Odds ratio at 5% significance level and the 95% confidence intervals. Factors for the infection were selected using forward step-wise variable selection method. Differences in proportions by age and sex were assessed by logistic regression and differences in means using a Chi-square test.

V. RESULTS

DEMOGRAPHIC CHARACTERISTICS

Out of the 442 children in 4 primary school children examined, 227(51.4%) were female and 215(48.7%) were male. Most of the children surveyed were in the age group of 8-10 years 219(49.2%) with the mean age of 9± 0.09 years and a range of 5-16 years.

PREVALENCE

The overall prevalence of *S. mansoni* was 11.7% (95% CI 8.7%-14.6%) while that of *S. haematobium* was 24.4 % (95%CI 20.4%- 28.4%), respectively. The difference in prevalence between the two species was highly significant (Wald test, P <0.001). The prevalence of *S. haematobium* was significantly higher in male as compared to female children (28.8% vs. 20.3%, P-0.05). On the other hand there was no significant difference in prevalence of *S.mansoni* between sexes, as seen in Table 1.

The prevalence of *S. haematobium* was the highest among the age groups in 11-13 years at (26.8%), followed by the 8-10 years at (26.5 %). The prevalence of *S. mansoni* is highest among the age of > 13 years at (20%) and high among the age group of 11-13 years at (13.4%), followed by the 5-7 years at(13.2%), as seen in Table 1.

	S. haematobium		***S. mansoni***	
Category (n)	Prevalence (%)	95%CI	Prevalence (%)	95%CI
Overall (442)	24.4%	20.4-28.4	11.7%	8.7-14.8
Prevalence by gender				
Male (215)	28.8%		12.1%	7.7-16.5
Female (227)	20.3%	22.7-34.9	11.5%	7.3-15.5
		15.0-25.5		
Prevalence by age groups				
5-7(106)	17.9%		13.2%	6.7-19.6
8-10 (219)	26.5%		10.0%	6.1-14.0
11-13 (112)	26.8%		13.4%	7.1-19.7
>13 (5)	20.0%	10.6-25.2	20.0%	0.0-55.1
		20.6-32.3		
	24.5%		5.8%	1.8-9.6
Prevalence by school				
Kiwalwa (139)	25.7%	18.6-34.9	14.3%	7.5-21.0
Abori (105)	21.4%		15.3%	8.2-22.4
Lotima (98)	26.0%	0.0-55.1	14.0%	7.2-20.8
Eldoro (100)		17.3-31.6		
		17.3-34.1		
		13.3-29.5		
		17.4-34.6		

Table 1: The infection status of S. haematobium and S. mansoni in the study sample

INTENSITY OF INFECTIONS

The intensity of infection was calculated in the form of geometric mean eggs per gram of feaces (epg) for *S. mansoni* and mean egg output per 10ml of urine for *S. haematobium* shown in Table 2. The mean intensity for *S.mansoni* was 28.40 eggs/gm while for *S. haematobium* it was 2.16 eggs/10 mls urine.

Infection	**Mean intensity (Geometric)**	**95%CI**	**Standard deviation**	**Range**
S. mansoni	28.40	54.204-88.734	±1.65	0-528
S. haematobium	2.16	14.447-29.161	±4.93	0-1000

Table 2: The geometric mean intensity of infection of S. haematobium and S. mansoni in the study sample

Further the intensity threshold was categorised into heavy, moderate and light infections. This classification was based on the WHO criteria [9].

The intensity of infection at the school community level was calculated. For *S. mansoni* 0.22% had heavy intensity, 3.39% had moderate, while 8.14% had light intensities. For *S. haematobium* 7.23% of the population had heavy intensity while 17.19% had light infection intensity as seen in Table 3. Therefore, this indicated that a large number of the pupils who tested positive for *S. mansoni* and *S. haematobium* had light intensity thresholds.

	S. mansoni (n=442)		***S. haematobium(n=442)***	
	Prevalence	95% CI	Prevalence	95% CI
Heavy	0.22%	0.03%-1.28%	7.23%	5.67%-9.23%
Moderate	3.39%	1.54%-7.45%		
Light	8.14%	5.4%-12.2%	17.19%	14.52%-20.88%

Table 3: The intensity threshold of S. mansoni and S. haematobium among the study sample

DUAL INFECTIONS

Further analysis revealed that out of the 442 primary school children 24 had dual infection (both *S. mansoni* and *S. haematobium).* This is summarized in the Table 4.

Status of infection	**n(%)**
Double (both *S. mansoni and S. haematobium*)	24 (5.43%)
Single (either *S. mansoni or S. haematobium)*	112(25.34%)
No infection (neither *S. mansoni* nor *S. haematobium*)	306(69.23%)
Total	442

Table 4: The Dual infection status of the study sample

Among the children with dual infections, both genders almost similar percentages of dual infection. For the boys it was at 5.11% while the girls were at 5.72% as seen in Table 5. Although the infection did not differ significantly among the age groups, the 8-7 yrs age group had the highest percentage prevalence of dual infections followed by the 8-10 yrs age groups, the age group of 13 years and above did not have a single case of dual infections.

Category(n)	**Prevalence**	**95% CI**
Overall (442)	5.43%	3.67%-8.01%
Prevalence by Gender		
Female(227)	5.71%	3.37%-9.1%
Male(215)	5.11%	2.87%-9.09%
Age category		
5-7 yrs (106)	6.60%	3.95%-16.4%
8-10 yrs (219)	5.93%	4.67%-13.3%
11-13 yrs (112)	3.57%	1.36%-9.34%
>13 yrs (5)	0.00%	

Table 5: Prevalence of dual infection in relation to gender and age in the study population

Further, a multivariate logistic regression was done to check how age and gender factors had an influence the dual infection. None of these factors was found to significantly influence the infection of both *S. mansoni* and *S. haematobium*

AGE AND GENDER ASSOCIATION WITH *S. HAEMATOBIUM* AND *S. MANSONI* INFECTIONS

In an attempt to determine the factors contributing to *S. haematobium* and *S. mansoni* infections the forward variable method of variable selection was performed based on likelihood ratio on the multivariable logistic regression model. It was observed that the female children were significantly less likely to be infected with *S. haematobium* compared to male (OR-0.4896, p-value 0.031) as seen in Table 6. It is also worth noting that children in the 8-10 age groups, prevalence 10.0% were less likely to be infected with *S. mansoni* compared to the other age groups (OR -0.25, p-value 0.48) as seen in Table 7.

Factor		Odds Ratio	p-value	95%CI
Gender	Female vs Male	-0.49	0.031	-0.93 - -3.65
Age groups				
	8-10 vs 5-7	0.54	0.07	
	11-13 vs 5-7	0.49	0.13	-0.04-1.13
	>13 vs 5-7	0.01	0.99	-0.15-1.15
				-2.25-2.26

Table 6: Logistic regression model for S. haematobium

Factor		Odds Ratio	p-value	95%CI
Gender	Female vs Male	0.017	0.95	-0.57-0.61
Age groups				
		-0.25	0.48	
	8-10 vs 5-7	0.16	0.67	-0.97-0.47
	11-13 vs 5-7	0.65	0.57	-0.63-0.96
	>13 vs 5-7			-1.6-2.97

Table 7: Logistic regression model for S. mansoni

VI. DISCUSSION

This study demonstrates that schistosomiasis is still endemic in Taveta sub county, Kenya. The current study further reveals that indeed both *S. mansoni* and *S. haematobium* continue to be prevalent in Taveta region with *S. haematobium* registering higher prevalences at 24.3%, (95%CI 20.4%- 28.4%) than *S. mansoni* at 11.8% (95%CI 8.7%-14.6%). Similar prevalence situations have been observed different geographical areas in Kenya [10]–[13].

In terms of prevalence with age, this current study indicates that the age group of 11-13 years had a higher prevalence of *S. hematobium* than younger or older age groups. In the *S. mansoni* infected children on the other hand, prevalence was highest among the over 13 years age group. A study conducted by [6] in three villages in Taveta, reveals a parallel situation to this current study: that children display the highest rate of infection with schistosomiasis. The study further revealed that egg positive rates increase rapidly with age in children and reach a peak between the ages of 5-14years then gradually decrease. In the current study Primary school age children have served as an indicator of the infection status in Taveta population. A prevalence study conducted in Brazil revealed the advantage of conducting schistosomiasis prevalence survey using primary school age children [14]. The cluster of children at 6-15 years serves as a tool for comparative analysis of prevalence in that infection prevalence in this age group demonstrated the highest positive correlation with overall population prevalence. This age group is useful both as a target group and a reference point as it is the age range established for formal schooling in Kenya and many developing countries where Schistosomiasis is endemic. It is also worth noting that children in this age group are the main targets of WHA (World Health Assembly) Resolution 54.19, whose member countries, including Kenya, committed to the minimum goal of providing diagnostic coverage and treatment for helminth infection to 75% of school-aged children in endemic areas by the year 2010 [9]. Incidence and prevalence of infection observed from children in this age group may be used to evaluate not only the health situation of schistosomiasis in the schoolchildren, but also the need for intervention in the community as a whole [15]. It is also advantageous that the school infrastructure reduces the operational costs for parasitological surveys and medication administration because it concentrates activities in a specific physical space and, in addition, provides an excellent opportunity to reach non-enrolled children [16]. As noted critically in this study, targeting of this particular age group allows for the follow-up of the impact of treatment over the period of between one to three years before they leave school and children who test positive serve as a good indicator that could lead to the identification of infected family members, including non-enrolled children [17], [18]. A study conducted in the endemic area of Minas Gerais, Brazil, validated the use of prevalence among individuals in the 7-14 year-old age group to predict *S. mansoni* prevalence in the community, confirming that it can be used to guide treatment strategies in the endemic area [19].

In this study the prevalence of *S. haematobium* was found to be significantly higher in the male children as compared to the female children (28.8% vs. 20.3%, P-0.03). It was further noted that female children were significantly less likely to be infected with *S. haematobium* compared to male (OR-0.4896, p-value 0.031). Similar findings were reported from a study in Nigeria where the results showed that the males were generally more infected and with a higher intensity than the females [20]. This observation can be attributed to the fact that male pupils have higher water contact activities. It is also worth noting that other common water contact activities including playing, swimming, fishing, wading and bathing in cercariae infested water bodies are male dominated, whereas girls are more conservative especially when it comes to swimming in open water bodies as compared to boys.

In terms of dual infection, analysis revealed that out of the 442 primary school children 24 had dual infection (both *S.*

mansoni and *S. haematobium).* A study conducted 2008 in Taveta among 470 primary school children revealed 44% infection rate by either *S. mansoni*, *S. haematobium* or co-infection with both species [7]**.** As for the children with dual infection this study revealed no significant differences between boys and girls. While the infection did not differ significantly among the age groups, the 5-7yrs age group had the highest percentage prevalence of dual infections followed by the 8-10 age groups. Dual infection indicates that transmission of both intestinal and urinary schistosomiasis is rampant despite the ongoing annual national control programme in Kenya. This is a dire situation given that each infection has got its own pathology therefore double morbidity, which results in a double burden for an infected child

VII. CONCLUSION

Our study shows that schistosomiasis is still endemic in Taveta. In addition the area is endemic for dual infection therefore more stringent preventive measures need to be put in place so that uninfected children are protected, while those already infected get continuous treatment**.** This calls for an overhaul of public health control measures. The results of this study suggest that it is necessary not only for continued preventive and curative chemotherapeutic intervention in the primary school children, but also in the larger adult community, since the children are indeed an indicator of the prevalence situation in the entire community.

DECLARATIONS

ETHICS APPROVAL AND CONCENT TO PARTICIPATE

Consent to conduct this study was granted by the Kenya Medical Research Institute, Scientific Review Unit.

Protocol number SSC 2872

CONSENT FOR PUBLICATION

The Kenya national deworming programme is an ongoing yearly activity that has been taking place for more than 8 years. Before the programme begun, the parents, teachers, school administration from county governments in endemic areas were informed of the programme.

Before every exercise in this study, meetings were held with the county government of Taveta, department of education, the teachers and the local district hospital, to inform them about the exercise.

Parents and guardians gave permission for their children to take place in the study and they had the chance to ask questions and were informed that participation of their children in the study was completely voluntary and that they had the right to withdraw from the study at any time.

AVAILABILITY OF DATA AND MATERIAL

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request

COMPETING INTERESTS

The authors declare that they have no competing interests

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Analysis, interpretation and Manuscript are endeavours of the corresponding author.

AUTHORS CONTRIBUTIONS

IW principal investigator
WT Principal Supervisor
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DY Supervisor Technical University
AM Supervisor University of Nairobi
LN Statistician
IW assisted in editing manual

All authors read and approved the final version of the manuscript

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