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Journal of Infectious Diseases and Diagnosis

Research

Schistosomiasis and Soil Transmitted Helminthiases in Taita Taveta County, Kenya: Prevalence, Intensity and Association with Anaemia and Nutritional Status of Children under 5 Years

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ABSTRACT

With delayed treatment, schistosome and soil transmitted helminth (STH) infections in young children (<5 years) could potentially lead to irreversible lifelong detrimental health effects. This is because these infections are known to cause suboptimal growth and development in this critical phase of life. The present study sought to document the burden of schistosome and STH infections in Taita Taveta County, Kenya, by determining the prevalence and intensity of the infections in children less than 5 years of age. The study also appraised the association between infections with schistosomes, anaemia and nutritional status in children. A total of 132 children, 53.8% males, were enrolled in the survey. The number of children who were diagnosed with schistosomiasis was 37 (prevalence 28.0%; 95% confidence interval (CI) 21.1%-36.2%). Infections with *S. haematobium* and *S. mansoni* were detected in 18.9% (95% CI 13.2%-26.5%) and 15.9% (95% CI 10.7%-23.1%) of the surveyed children, respectively. Seventeen children tested positive for infection with any STH (prevalence 6.8%; 95% CI 3.6%-12.5%). Species-specific prevalences of STH were: *A. lumbricoides* (6.8%), hookworm (4.5%) and *T. trichiura* (1.5%). Four children (16.0%) had heavy intensity *S. haematobium* infections. No heavy intensity infections were detected in children who were infected with STH and *S. mansoni*. Nutritional indices which were associated with schistosome infections included stunting ((odds ratio (OR) 3.665 (95% CI 1.443-9.309), p=0.006) and being underweight (OR 12.698 (95% CI 3.107-51.900, p<0.001). Anaemia was more prevalent among children who tested positive for infections with schistosomes when compared with their schistosome-negative counterparts (57.1% vs. 42.9% respectively, OR 7.897 (95% CI 3.383-18.438), p<0.001). The study established that schistosome and STH infections are prevalent in children under 5 years in the study area thus presenting a potentially significant public health concern. The children should be prioritized for interventions including being incorporated in the mass deworming programme which currently targets school age children.

Keywords: Soil-transmitted helminths; Schistosomiasis; Mass drug administration; Neglected tropical diseases; Nutritional status; Anaemia; Children under 5 years

AUTHOR SUMMARY

Research has demonstrated that young children (less than 5 years) suffer from schistosomiasis and soil transmitted helminthiases (STH) in regions where the two diseases occur together. In spite of this, no interventions have been put in place to address this challenge. Current schistosomiasis and STH control programs focus exclusively on school-aged children. As a result the young children who are infected only receive treatment

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Received: March 10, 2020; **Accepted**: March 24, 2020; **Published**: March 31, 2020

Citation: Ngaluma PN, Arodi WO, Gachara GM, Kihara JH, Nga'ng'a MP (2020) Schistosomiasis and Soil Transmitted Helminthiases in Taita Taveta County, Kenya: Prevalence, Intensity and Association with Anaemia and Nutritional Status of Children under 5 Years. J Infect Dis Diag. 5:131. DOI: 10.35248/2576-389X.5.131

on attaining school age. By this time, significant negative health effects will have taken place. Furthermore lack of treatment for this group contributes considerably to the sustenance and transmission of the infections in the community. The current study confirmed schistosomiasis and STH to be prevalent among the young children thus adding to the accumulating body of evidence highlighting the substantial burden of the two diseases and the need to institute appropriate remedial measures. Specifically, this study emphasizes the urgent need to integrate the young children in the current efforts aimed at preventing and controlling these diseases including the ongoing mass drug administration programme.

INTRODUCTION

Infection with schistosome and soil transmitted helminths (STH) remain a key public health challenge in sub-Saharan Africa. The two infections are closely linked to poverty in addition to inadequate safe water, sanitation and hygiene [1]. Though these infections are prevalent in all age groups, preschool age children (PSAC), school age children (SAC) and women of reproductive age are considered to be at high risk of morbidities associated with STH and schistosome infections [2]. Chronic infections with STH and schistosomes compromise growth, development, cognition, iron status and naivety of immune system which further increase susceptibility to infections [3]. Blood losses from haematuria and faecal occult blood from schistosome infections affects iron balance causing anaemia. Additionally, STH given their distinctive niche perpetually deprive the host vital nutrients [4]. Research studies in PSAC have demonstrated that STH and schistosome infections occur in early childhood, and if untreated can lead to undesirable health consequences later in life [5,6]. Furthermore, it has been observed that a substantial population of PSAC are at risk of infections with schistosomes and STH. For instance, according to Albonico and colleagues [3] about 10% to 20% of the 3.5 billion people residing in areas where STH endemic are PSAC.

Furthermore, it is estimated that out of the 123 million children suffering from schistosome infections worldwide, about 50 million are PSAC [7]. Despite PSAC being classified as a group at high risk of morbidities linked with schistosome and STH infections, the main focus for treatment has been SAC [2]. Dearth of published research on the burden of schistosome and STH infections in PSAC is to blame, at least partially, for the exclusion of this age group from the current programs aimed at controlling and eliminating infections with schistosomes and STH. This is of great concern bearing in mind that PSAC are nutritionally vulnerable section of the population and defects arising during this developmental stage may persist for long and sometimes throughout life [4]. The present study aimed to determine the prevalence and intensities of infections with schistosome and STH among PSAC in an area which is known to be endemic for the two infections [8-10]. The study also examined the burden of anaemia in this age group as well as growth and nutrition-related morbidities associated with schistosome and STH infections.

METHODS

Ethical statement

Relevant scientific and ethical reviews and approvals were provided by the Kenyatta University. Written informed consents were obtained from the mothers whose children participated in the study. Permission to undertake the study was granted by the Ministry of Health (MoH), Taita Taveta County. All children who were found positive for infections with schistosomes and/or STH were treated in a local public health facility according to MoH guidelines.

Study site

The study was conducted at Taveta Sub-county of Taita Taveta County. Taita Taveta County is one of the six Counties in the Coastal region of Kenya. It is located approximately 200 Km northwest of the coastal city of Mombasa and 360 km southeast of Nairobi, the capital city of Kenya. It borders Kitui and Makueni Counties to the North, Kwale and Kilifi Counties to the East, Kajiado County to the North-west, and the Republic of Tanzania to the South and South-west. The County covers an area of 17,084.1 Km2 and lies between latitudes 2° 46` South and 4° 10`South and longitudes 37° 36` East and 30° 14` East. As of 2019 national census, the estimated population of the county was 340,671. The population for children under five years was estimated to be 37,780 in 2009 with population projections for this age group, for 2015 and 2017, being 39,663 and 41,646 respectively [11].

Study design and population

The present health-facility based cross-sectional study design recruited children below 5 years consecutively as they sought services in public health facilities within Bomani Ward of Taveta Sub-county. The inclusion criteria included being a resident of the study area for at least 12 months and the caregiver providing consent for the child to take part in the research. Children who were critically ill were excluded from the study.

Sample and data collection procedure

Data on demographic characteristics (age and sex) and nutritional status (weight, height, length, and mid-upper arm circumference (MUAC) were captured on a data collection form as the samples were being collected. Universal bottles were provided to the parents/caregiver for collection of urine and faecal samples. The Stool samples were processed by Kato Katz technique [12]. Slides of the resultant smears were examined microscopically. Presence and number of species of parasitic eggs observed were recorded. Urine samples were collected between 1000 and 1400 hours and processed using urine filtration method as described by Mott and others [13]. Briefly, urine samples were agitated to ensure adequate dispersal of eggs. Ten mL of urine was drawn using a syringe and passed through Nucleopore-H filters. The filters were then mounted on a microscope slide. Microscopic examinations were performed and the presence and number of *S. haematobium* eggs noted. Blood samples were tested for malaria parasite antigen using SD

Bioline Malaria Ag P.f/Pan (Standard Diagnostics Inc., Korea), RDT kits as outlined in the manufacturers' instructions inserts. Haemoglobin concentration was determined using 301 HemoCue analyzer (Anglom, Sweden).

Data management and statistical analysis

Intensities of STH and schistosome infections were stratified according to the cut-offs defined by the WHO guidelines [2]. Anaemia was defined as hemoglobin<11 g/dl [14]. Appropriate anthropometric indices including weight-for-age z-scores (WAZ), weight-for-height z-scores (WHZ) and height-for-age z-scores (HAZ) were computed based on WHO's child growth standards [15]. Analysis of nutritional data was performed using WHO Anthro 3.2.2. Other statistical analyses were done using IBM SPSS Statistics 22.0. Normally distributed continuous data were described using mean ± standard deviation (sd). Continuous data which were not normally distributed were described using median and interquartile range (IQR). Categorical variables were described using absolute numbers and corresponding proportions. Chi-square (x 2) test, or Fisher's exact test where appropriate, were used to test associations between the independent variables and the dependent variable. A p-value of less than 0.05 was set as the threshold of statistical significance in all hypotheses tests.

RESULTS

Demographic characteristics of the study participants

Analysis of the demographic characteristics of the 132 children (<5 years) who took part in the current survey showed that the age of the enrolled children ranged from 7 to 59 complete months. Majority of the surveyed children were male (53.8%). The median (IQR) age was 48 (39-59) months. Those who were aged between 24 and 48 months were 43.2% while those aged less than 24 months comprised 47.7% of the study participants. The rest (9.1%) were aged more than 48 months.

Nutritional status of the enrolled children

The findings on the nutritional status of the enrolled children are displayed in Table 1. Wasting and stunting was observed in 15.2% and 17.4% of the sampled children respectively. Children who were underweight comprised 8.3% of the study participants. The mean ± standard deviation (sd) haemoglobin concentration was 11.6 ± 1.25 g/dl (range: 8.7 to 16.7 g/dl). The haemoglobin concentration did not differ significantly by sex (11.6 ± 0.14 g/dl boys and 11.6 ± 0.16 g/dl for girls, p=0.922). The overall prevalence of anaemia was 31.8%. (95% CI 24.5%-40.2%). Children whose MUAC z-scores were classified as low (<-2 z scores) were 7.6%. The prevalence of thinness in the surveyed children as indicated by BMI-for-age z-scores was 29.5%.

Table 1: Nutritional status of the study participants.

Attribute	Category	Number (n=132)	%
Weight-for-length/height scores	z- Wasting (<-2 z-scores)	20	15.2
	Normal (≥ -2 z-scores)	112	84.8
Length/height-for-age z-scores	Stunting (<-2 z-scores)	23	17.4
	Normal (≥ -2 z-scores)	127	96.2
Weight-for-age z-scores	Underweight (<-2 z-scores)	11	8.3
	Normal (≥ - 2 z-scores)	121	91.7
BMI-for-age Z scores	Thin (<-2 z-scores)	39	29.5
	Normal (≥ - 2 z-scores)	93	70.5
MUAC Z scores	Low (<-2 z-scores)	10	7.6
	Normal (≥ - 2 z-scores)	122	92.4
Haemoglobin level	Anaemic (<11 g/dl)	42	31.8
	Normal (≥ 11 g/dl)	90	68.2
Haemoglobin (mean ± standard deviation)		11.6 ± 1.25 g/dl	

Prevalence of helminthic infections

The proportion of study participants who were positive for schistosomiasis was 28.0% (95% confidence interval (CI) 21.1%-36.2%). The prevalence of infections with *S. haematobium* and *S. mansoni* were 18.9% (95% CI 13.2%-26.5%) and 15.9% (95% CI 10.7%-23.1%) respectively. Infection with either of the two species of schistosomes was reported in 28 children (21.2%). Nine children had co-infections with both species of schistosomes (6.8%). A total of seventeen children were infected with any of STH species (prevalence of 12.9% (95% CI 8.2%-19.7%); Further, the prevalences of infections with STH species were as follows: *A. lumbricoides* 6.8% (95% CI 3.6%-12.5%), hookworm 4.5% (95% CI 2.1%-9.6%), and *T. trichiura* 1.5% (95% CI 0.4%-5.4%). These distribution of the infections with helminths among preschool age children is illustrated in Figure 1.

Intensity of helminthic infections

The intensity of *S. haematobium* infections varied from a minimum of 4 eggs/10 ml of urine to a maximum of 98 eggs/10 ml of urine (mean ± standard error intensity: 32.4 ± 4.94 eggs/10 ml of urine). Of the 25 children infected with *S. haematobium*, 20 (80.0%) and 5 (20.0%) children had light intensity (1-49 eggs/10 ml urine) and heavy intensity (≥ 50 eggs/10 ml urine) infections respectively. Twenty one children tested positive for *S. mansoni*, out of which sixteen (76.2%) had light intensity infections (1-99 egg of stool) while the rest (5, 23.8%) had infections of moderate intensity (100-399 egg). The mean ± standard error intensity of *S. mansoni* was 71.7 ± 12.88 egg of stool (range 12-240 egg). All STH infections were of light intensity as shown in Table 2.

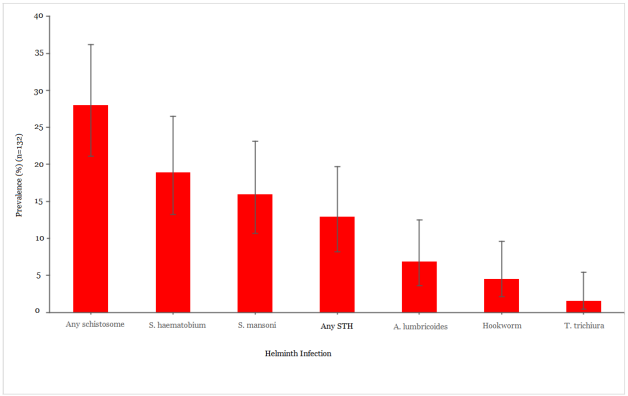

Figure 1: Prevalence of infection with helminths in preschool age children. The error bars indicate 95% confidence intervals.

Table 2: Intensity of helminthic infestations.

Parasite	Intensity	Number	%
Hookworm (n=6)	Light (1-1,999 egg)	6	100
	Moderate (2,000-3,999 egg)	0	0
	Heavy (≥ 4,000 egg)	0	0
A. lumbricoides (n=9)	Light (1-4,999 egg)	9	100
	Moderate (5,000-49,999 egg)	0	0
	Heavy (≥ 50,000 egg)	0	0
T. trichiura (n=2)	Light (1-999 egg)	2	100
	Moderate (1,000-9,999 egg)	0	0
	Heavy (≥ 10,000 egg)	0	0
S. mansoni (n=21)	Light (1-99 egg)	16	76.2
	Moderate (100-399 egg)	5	23.8
	Heavy (≥ 400 egg)	0	0
S. haematobium (n=25)	Light (1-49 eggs/10 ml urine)	21	84
	Heavy (≥ 50 eggs/10 ml urine)	4	16

Analysis of the variations of the prevalences of infections with helminths by age of the children

Investigations of the distribution of helminths infections by age of the study participants showed that a higher proportion of older children (36-59 complete months) were infected with *S. mansoni* when compared to their younger counterparts (<3 years) (28.6% vs. 12.3% respectively, p=0.039). Moreover, *S. haematobium* infections were more prevalent among the older children than among their younger equals (32.1% against 15.4% respectively, p=0.045). Children who were diagnosed with either one or both species of schistosome comprised 21.2% of the children in the younger age group and 53.6% of children in the older age category (p=0.001). The distribution of STH infestations including hookworm, *A. lumbricoides* and *T. trichiura* did not vary significantly with the age of the study participants (Table 3).

Table 3: Results of the analysis of parasitic infections and age of the study participants.

Infection	Age [n (%)]		p value
	<3 years	**3- <5 years**	
S. mansoni			
Positive	13 (12.5)	8 (28.6)	0.039
Negative	91 (87.5)	20 (71.4)	
S. haematobium			
Positive	16 (15.4)	9 (32.1)	0.045
Negative	88 (84.6)	19 (67.9)	
Schistosome infection			
Positive	22 (21.2)	15 (53.6)	0.001
Negative	82 (78.8)	13 (46.4)	
Any STH			
Positive	15 (14.4)	2 (7.1)	0.307
Negative	89 (85.6)	26 (92.9)	
A. lumbricoides			
Positive	7 (6.7)	2 (7.1)	0.939
Negative	97 (93.3)	26 (92.9)	
Hookworm			
Positive	3 (2.9)	3 (10.7)	0.077
Negative	101 (97.1)	25 (89.3)	
T. trichiura			
Positive	1 (1.0)	1 (3.6)	0.316
Negative	103 (99.0)	27 (96.4)	

Distribution of the infections with helminths by the sex

Significantly more males than females were positive for infections with *S. mansoni* (22.5% vs. 8.2% respectively, p=0.025), *S. haematobium* (respectively, 25.4% and 11.5%, p=0.042) and at least one species of schistosome (38.0% in males and 16.4% in females, p=0.006). Prevalences of STH infections were no different when analyzed by sex of the study participants (Table 4).

Table 4: Results of the analysis of parasitic infections and the sex of the study participants.

Parasite	Sex [n (%)]		p value
	Male	Female	
S. mansoni			
Positive	16 (22.5)	5 (8.2)	0.025
Negative	55 (77.5)	56 (91.8)	
S. haematobium			
Positive	18 (25.4)	7 (11.5)	0.042
Negative	53 (74.6)	54 (88.5)	
Schistosome infection			
Positive	27 (38.0)	10 (16.4)	0.006
Negative	44 (62.0)	51 (83.6)	
Any STH			
Positive	10 (14.1)	7 (11.5)	0.655
Negative	61 (85.9)	54 (88.5)	
A. lumbricoides			
Positive	5 (7.0)	4 (6.6)	0.912
Negative	66 (93.0)	57 (93.4)	
Hookworm			
Positive	4 (5.6)	2 (3.3)	0.517
Negative	67 (94.4)	59 (96.7)	
T. trichiura			
Positive	2 (2.8)	0 (0.0)	0.187
Negative	69 (97.2)	61 (100.0)	

Association between schistosomiasis and nutritional status of the study children

Table 5 shows the results of the effects of schistosome infections on the nutritional status of the children who participated in the current study. Stunting was significantly associated with schistosomiasis with prevalence of schistosome infections being higher in children who were stunted compared to the ones who were not stunted (52.2% against 22.9% respectively, odds ratio (OR) 3.665 (95% CI 1.443-9.309), p=0.005). Additionally, children who were underweight had approximately nine-fold higher odds of being diagnosed with schistosomiasis (OR 8.460 (95% CI 2.105-33.999), p=0.001). The prevalence of anaemia was significantly higher among those who were diagnosed with schistosome infections when compared to those tested negative with the former having about three-fold higher odds of being anaemic (57.1% vs. 14.4% respectively, OR 7.897 (95% CI: 3.383-18.438), p<0.001). Furthermore, there were significant variations in the haemoglobin concentrations between the two groups (infected and non-infected) (mean ± standard error (se): 10.6 ± 0.15 g/dl against 11.9 ± 0.10 g/dl for those who were positive and negative for schistosomiasis, respectively, p<0.001). Thinness as indicated by BMI-for-age z-scores was not significantly associated with prevalence of schistosomiasis (OR 0.696 (95% CI 0.412-0.657), p=0.412). Additionally, wasting and MUAC were not significant predictors of the schistosomiasis infection status in the study group (p=0.451 and p=0.381 respectively).

DISCUSSION

The findings from current cross sectional survey highlights a significant burden of infections with schistosome and STH among PSAC living in the study area. In this study, about one in three children was found to be infected with one or both species of schistosomes. Approximately one-tenth of the PSAC had concurrent schistosome infections while one-quarter of the PSAC had infections with *S. haematobium*. One out of every five PSAC examined was positive for infection with *S. mansoni*. Besides, STH infections were reported in more than one-tenth of the children who participated in the study. The findings adds to the growing body of evidence supporting the call for inclusion of PSAC in the schistosomiasis and soil transmitted helminthiasis control programs.

A review of literature indicates wide variations in estimates of the burden of schistosome and STH infections among PSAC. This could be explained by the differences in both environmental and host specific factors that may impact on the transmission of these infections. These may include population heterogeneity, genetics, age, poly-parasitism, temporal aspects, geographic settings, parasitological method used, personal hygiene practices, climate and altitude among others. Contrary to our findings, a study done in Ethiopia reported a higher prevalence of STH infections among PSAC (23.3%) with *A. lumbricoides* being the predominant STH species (14.9%)

followed by *T. trichiura* (6.4%) and hookworm (3.2%) [16]. The disparities in the results from the two studies could be partially attributed to the differences in the settings of the two surveys: the Ethiopian research was community based whereas the current study was undertaken in health facilities. Indeed, a hospital-based study carried out in the same country reported prevalences which are not very different from what was found in this study: infections with *A. lumbricoides* and *T. trichiura* were 10.8% (95%CI 6.6%-15.1%) and 1.4% (95% CI 0.0%-3.0%) respectively [17]. Infections with STH were detected in 26.5% PSAC in Hoima district, Uganda; hookworm infection was the most prevalent STH (18.5%) [18]. The higher prevalences could most probably be due to the differences in transmission rates and environmental conditions in the two study areas. On the other hand, the Ugandan study reported similar prevalences of infections with regard to *A. lumbricoides* (9.8%) and *T. trichiura* (0.5%) when compared to the current study [18].

The prevalence of *S. haematobium* recorded in this study (18.9% 95% CI 13.2%-26.5%) is no different compared to the 19.8% reported by a team led by Opara [19] in a research that focused on pre-school children in Nigeria. However, our estimate is slightly higher compared to the prevalence of 11.2% reported among infants in Ghana [20]. The Ghanian study recruited much younger children compared to our study (included children aged six months and below) and this may be the one of the reason for the discordance in the findings. The younger children have lesser exposure to the infections compared to the elder ones hence a lower likelihood of being infected.

Table 5: Assessment of the effect of schistosome infections on the nutritional status of children.

Nutritional status	Schistosomiasis [n (%)]		OR (95% CI)	p value
	Positive	Negative		
Weight-for-length/height z-score)				
Wasting (<-2 z-scores)	7 (35.0)	13 (65.0)	1.472 (0.536-4.039)	0.451
Normal (≥ -2 z-scores)	30 (26.8)	82 (73.2)	REF	
Length/height-for-age z-scores				
Stunting (<-2 z-scores)	12 (52.2)	11 (47.8)	3.665 (1.443-9.309)	0.005
Normal (≥ -2 z-scores)	25 (22.9)	84 (77.1)	REF	
Weight-for-age z-scores				
Underweight (<-2 z-scores)	8 (72.7)	3 (27.3)	8.460 (2.105-33.999)	0.001
Normal (≥ - 2 z-scores)	29(24.0)	92(76.0)	REF	
BMI-for-age Z scores				
Thin (<-2 z-scores)	9(23.1)	30(76.9)	0.696(0.293-1.657)	0.412
Normal (≥ - 2 z-scores)	28 (30.1)	65 (69.9)	REF	
MUAC Z scores				
Low (<-2 z-scores)	4 (40.0)	6 (60.0)	1.798 (0.477-6.776)	0.381
Normal (≥ - 2 z-scores)	33 (27.0)	89 (73.0)	REF	
Haemoglobin level				
Anaemic (<11 g/dl)	24 (57.1)	18 (42.9)	7.897 (3.383-18.438)	<0.001
Normal (≥ 11 g/dl)	13 (14.4)	77 (85.6)	REF	
Haemoglobin				
(mean ± standard error (g/dl))	10.6 ± 0.15	11.9 ± 0.10		<0.001

Our findings on hookworm prevalence (4.5%) was much higher compared to those reported in rural KwaZulu-Natal, South Africa where prevalence of hookworm was 1.6%. The South African study, however, found higher prevalence of *A. lumbricoides* (18.3%). On the other hand, the prevalence of *T. trichiura* (1.2%) in the study was not very different from what was found in the present study [21]. The prevalence of *S. mansoni* in this study (15.9%) was lower compared to that of a research done in North-Western-Tanzania where the proportion of PSAC infected with *S. mansoni* was 44.4% (95% CI 39.4%-49.4%) [22]. The differences may be due to the age of the study participants whereby the latter study enrolled PSAC of between one and six years of age while in the present research PSAC's age ranged from seven to 59 months. Research on helminth infections among PSAC conducted in Tanzania reported findings which are in concordance with those of the current study with Schistosoma spp. being the predominant helminth species (prevalence 15.8%; 95% CI 12.1-20.3%). Conversely, the Tanzanian study reported a significantly lower burden of *S. haematobium* infections among PSAC (1.0%) [23]. The difference could partly be attributed to disparities in the study settings. Unlike the present research which was done in the rural area, the Tanzanian study was done in an urban set up. The dissimilarities in the findings between the two studies could also be a reflection of the differences in the abundance of intermediate hosts of *S. haematobium* (Bulinus spp.) in the two study sites.

A research on PSAC recruited around Mbita Causeway, Western Kenya, found that 45.1% of the children were infected with *S. mansoni* (95% CI 41.7%-48.5%) [24]. The higher burden of schistosomiasis observed in this study is not surprising considering that the Causeway has been documented to be a hotspot characterized by high intensity of transmission of schistosomiasis.

Until recently when it was demolished to pave way for a bridge, the artificial pathway of the Causeway contributed to the increased numbers of *S. mansoni* host snails due to obstruction of the waterway hence elevating the risk of transmission of schistosome infections [25]. Compared to our study, the prevalence of hookworm (1.1%, 95% CI 0.4%-1.8%) and *A. lumbricoides* (1.8%, 95% CI 0.9%-2.8%) was lower in the Western Kenya study while the no difference in the burden of *T. trichiura* reported in both studies (1.1%, 95% CI 0.4%-1.8%) [24]. Individuals with mixed infections tend to experience more severe infection-related morbidities. In the current research, concomitant infections with S.*haematobium* and S.*mansoni* were detected in 6.8% of PSAC. 28.6% (22.3%-35.7%). Simultaneous infections with both forms of schistomiasis among PSAC were also reported in a study conducted in Niger [26].

Generally, heavy intensity infections with helminths (both schistosome and STH) were not common among PSAC who took part in our study. Only five PSAC (3.8%) had infections of heavy intensity and these were specifically *S. haematobium* infections. Analogous observations were made by a research conducted in Uganda which noted no heavy intensity infections with *A. lumbricoides* and *T. trichiura* among PSAC [18]. The prevalence of heavy-intensity infections with *A. lumbricoides* and *T. trichiura* was 18.2% and 11.7% respectively, in a study that involved PSAC in Philippines No heavy-intensity hookworm infections were observed in this study [27].

Research among PSAC in Mbita Causeway, Mbita, Kenya reported the following proportion of intensities of infections with *S. mansoni*: light 28.9% (95% CI 25.8%-32.0%), moderate 10.6% (95% CI 8.4%-12.7%) and heavy 5.7% (4.1%-7.3%). The infections with STH were all of light intensity [24]. The dissimilarity in these findings with those of the present survey could be ascribed to differences of contact patterns of humans to infested waters, the presence and abundance of competent intermediate host snail, availability and abundance of suitable habitats for the intermediate snail hosts, the level of freshwater contamination with stool and/or urine containing eggs with miracidium and also the variations of immunity of human hosts [28].

Chronic anaemia acquired in early in life is associated with impairments in overall physical growth, cognitive development and poor school performance, later in life [29]. Besides, severe anaemia accounts for up to one-half of the mortalities in children aged less than 5 years [30]. Our study showed that approximately one-third of the studied PSAC were diagnosed with anaemia and the burden of anaemia was higher among PSAC who tested positive for schistosome infections.

This is in agreement with a study carried out in Niger, which concluded that *S. haematobium* infections increased the risk of anaemia by 30% [31]. Similarly, a study from Tanzania, reported that haemoglobin concentration in infected children was 0.4 g/dl lower than in uninfected children [32]. The findings are also in agreement with those of a study carried out in Uganda where a significantly higher proportion of *S. mansoni* positive children were anaemic (52.3% in the infected group and 35.2% in the uninfected group, $p<0.005$) [33]. The results are consistent with the conventional knowledge that schistosomiasis is among the myriad causes of anaemia. Even though malaria and hookworm infections are also known to cause anaemia, their prevalence, in the present study, was marginal. Moreover, the intensities of infections with hookworm were low. The findings are not surprising because malaria and hookworm infections are not common in children under five years of age; rather they are more prevalent in adults and older children [34].

About one out of every five PSAC who took part in the study was stunted. Stunting was more prevalent in PSAC who had schistosome infections. In addition, approximately one-tenth of the PSAC were underweight with higher odds of being underweight being recorded among PSAC in the schistosomiasis positive group. A study among PSAC in Zimbabwe indicated higher prevalences of malnutrition in this age group; underweight (prevalence 10.1% (95% CI 8.5% to 11.9%), and stunting (prevalence 18.0% (95% CI 16.0% to 20.3%). Consistent with the present study findings the Zimbabwean study found that, on comparing infected and uninfected children, prevalence of stunting was significantly higher among PSAC who had schistosome infections (27.0%; 95% CI 19.9% to 35.6% and 17.0%; 95% CI 14.9% to 19.4% respectively, $p=0.009$) [35].

The proportion of PSAC who were stunted, underweight and exhibiting wasting/thinness were 39.5%, 22.8% and 11.4%

respectively according to a study done in Southwest Nigeria. In this study, there was no significant association between the nutritional indicators and intestinal schistosomiasis and soil transmitted helminthiasis [36]. The wide disparities in findings most probably mirrors the socioeconomic status in the study settings.

The current study is not without limitations. The history of deworming of the children who were studied was not recorded and this represents a potential confounder in the relationships that were investigated in the current study. Additionally, due to resource limitations, only one sample of stool and urine was taken from the study participants. This could have led to under-estimation of the actual burden of helminthiases attributed to intermittent variations in excretion of eggs by the parasites. Furthermore, the diagnostic method used in the study (Kato Katz technique) is not considered to be highly sensitive, particularly in low intensity infections.

CONCLUSION

A significant burden of schistosomiasis and STH among children aged less than five years was observed in the study area. The study demonstrates unequivocally that the PSAC in this area need to be prioritized for interventions including mass treatment. For example, in line with WHO recommendations, since the egg patent prevalence of schistosomiasis in this age group is within the WHO-defined range of more than 10% but not exceeding 50%, then biennial treatment with praziquantel should be conducted [2]. With the WHO's ambitious goal of reaching 75% coverage of preventive chemotherapy targeting major helminthiases among PSAC [37], the findings from this study emphasizes the need for urgent planning and implementation of specific interventions to prevent further morbidity and to improve health of children. Our data support the call for institutionalized MDA in lieu of school-based approaches only. This will ensure that deserving PSAC are reached by pertinent interventions via alternative delivery platforms such as through the Integrated Management of Childhood Illnesses and through ECDEC.

ACKNOWLEDGEMENTS

Special thanks to the health care providers at Taveta Sub-county who took part in this study. We also acknowledge all the study participants and their caregivers for the wonderful support.

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