Original Article

Asian Pacific Journal of Tropical Medicine

Prevalence and intensity of urinary schistosomiasis and soil−transmitted helminths among women of reproductive age in Mwaluphamba, Kwale

Samuel M. Ngui[1✉], Joseph M. Mwangangi[2], Joachim Richter[3,4], Josephine W. Ngunjiri[5]

[1]Department of Biological Sciences, University of Embu, Kenya

[2]Medical Entomology, Kenya Medical Research Institute (KEMRI), Center for Geographic Medicine Research Coast Kilifi, Kenya

[3]Institute of International Health, Global Health Center, Charité University Medicine, Berlin, Corporate Member of Free University and Humboldt University and Berlin Institute of Health, Berlin, Germany

[4]Swiss Tropical and Public Health Institute, Basel, Switzerland

[5]Tropical and Infectious Diseases, Department of Biological sciences, University of Embu, Kenya

ABSTRACT

Objective: To assess the epidemiology of urinary schistosomiasis and soil-transmitted helminthiasis among women of reproductive age in Mwaluphamba, Kwale County, Kenya.

Methods: A community-based cross-sectional study design was employed to randomly sample 422 women of reproductive age (15-<50 years) from four villages in Mwaluphamba location. Stool specimens were collected and examined using the Kato-Katz method, while filtration technique was used to analyze urine specimens. Participants' sociodemographic details were obtained using a standardized questionnaire.

Results: Urinary schistosomiasis prevalence was at 4.7% (20/422, 95% *CI* 2.8%-6.9%) while the prevalence of soil-transmitted helminthiasis infection was 4.5% (19/422, 95% *CI* 2.6%-6.7%). The infection intensities of urinary schistosomiasis among the study participants ranged from 1 to 120 eggs/10 mL of urine with median egg count of 18.45 eggs/10 mL. The patients were diagnosed with light infection, of 56.16 egg/gram and 48.48 egg/gram for *Trichuris trichiura* and hookworms, respectively. Women without latrines had 15.7 times higher risk of having urinary schistosomiasis compared to those with a latrine. Similarly, use of surface water (a*OR*=1.0, 95% *CI* 0.2-1.4, *P*=0.010) and crossing the river to go to a place (a*OR*=1.1, 95% *CI* 0.3-1.6, *P*=0.009) were statistically significant risk factors for getting urinary schistosomiasis. In bivariable regression analysis, defecating around the water source (*OR*=4.3, 95% *CI* 1.5-12.9) had a statistically significant association with the prevalence of soil-transmitted helminthiasis (*P*=0.008).

Conclusions: This study has given an insight on the prevalence and intensity of urinary schistosomiasis and soil-transmitted helminthiasis in Mwaluphamba location that form a basis for strengthening the control and elimination programmes for these neglected tropical diseases.

1. Introduction

Schistosomiasis, also known as bilharzia, and soil-transmitted helminth (STH) infections [including hookworms, *Ascaris (A.)*

Significance

This study aimed to investigate the epidemiology of urinary schistosomiasis and soil-transmitted helminthiasis among women of reproductive age in Mwaluphamba, Kwale County, Kenya. The findings revealed a prevalence of 4.7% for urinary schistosomiasis and 4.5% for soil-transmitted helminthiasis, indicating ongoing transmission in the region. Significant associations were observed between urinary schistosomiasis and factors such as lack of latrines, use of surface water, and crossing rivers. Understanding these dynamics is crucial for designing targeted interventions to control and eliminate these neglected tropical diseases, especially among vulnerable populations like women of reproductive age, thereby improving their health and well-being.

✉To whom correspondence may be addressed. E-mail: mutuasamuel81@gmail.com

lumbricoides*, and *Trichuris (T.) trichiura*] are the most common parasitic infections in the world[1]. Globally, around 2 billion people are suffering infections of either one STH species. The World Health Organization (WHO) estimates that approximately 819 million people are infected with *Ascaris*, 464 million with *Trichuris*, and 438 million with hookworms[2]. Schistosomiasis is caused by *Schistosoma* species, and it's relatively common globally, particularly in developing countries. Humans are usually infected by five *Schistosoma* species such as *Schistosoma (S.) mansoni, S. haematobium, S. japonicum, S. mekongi,* and *S. intercalatum*; however, *S. mansoni* and *S. haematobium* are the most common species in Sub-Saharan African region[3]. Based on the recent estimates, 779 million people are at risk of infection, with Africa accounting for 85% of them. Approximately 207 million people in 74 countries are infected by these species, and 120 million of them develop the disease[4]. In Sub-Saharan Africa, schistosomiasis is responsible for over 200 000 annual deaths[5]. Helminthic infections are related to a variety of social, environmental, and other causes, including lack of basic health-promoting skills, overcrowding, poor access to safe water, tropical climate, and low altitude[6].

Schistosomiasis and STH are prevalent diseases in Kenya, where schistosomiasis affects an estimated 6 million people, the majority of whom are women and children; whereas STH affects 10 million people[7]. Schistosomiasis is caused by *Schistosoma* parasites, with *S. mansoni* and *S. haematobium* being the common species responsible for intestinal and urinary schistosomiasis, respectively. It is endemic in areas with freshwater bodies, including regions within Nyanza, Western, Coast, and Rift Valley provinces. In contrast, STH, caused by various soil-transmitted helminths, particularly *A. lumbricoides*, *T. trichiura* and hookworms affects numerous Kenyan communities, especially in rural and impoverished areas[8]. Kenya has been running a National School-Based Deworming program since 2012, which involves treating all school-aged children for STH and schistosomiasis in all primary schools in 28 endemic counties dispersed throughout different parts of Kenya through an Mass Drug Administration program[9,10]. A rigorous monitoring and evaluation program has been used to closely monitor the program's effect on parasitological outcomes in the treated children. The first five years of the monitoring were carried out between 2012 and 2017[11]. However, it is typically understood that the impact of such a large-scale national program is affected by a variety of factors, some of which are beyond the program's control[12]. Furthermore, it has been demonstrated that the availability of water, sanitation, and hygiene (WASH), as well as related practices and behaviours, affect the frequency of exposure to infectious materials in the environment (such as ova and larvae)[13].

The coastal strip in Kenya is hyper-endemic for urinary schistosomiasis but with substantial spatial and temporal differences[14]. Impoverished rural communities are more prone to schistosomiasis, especially areas where fishing and agriculture are the main economic activities. In the male and female urinary systems, untreated urinary schistosomiasis infection may cause painful urination, haematuria, and inflammatory and granulomatous lesions[15]. A patient suffering from acute schistosomiasis normally recovers within weeks, and the worms begin laying eggs around 5-7 weeks after the initial infection, resulting in the chronic stage of schistosomiasis. Female genital schistosomiasis is a chronic infection that results from *S. haematobium* and it's characterised by a wide range of gynaecological symptoms and signs in women[16]. Grainy and homogeneous yellow sandy patches, and rubbery papules are all clinical features of female genital schistosomiasis[17]. Female genital schistosomiasis, if not treated can result in infertility, miscarriages, ectopic pregnancies, abortions, stigmatization, nodules around the vulva, and the genital lesions[18]. Several epidemiological studies have shown that female genital schistosomiasis is responsible for horizontal transmission of HIV/AIDS among women of reproductive age[19], while a regression analysis of prevalence of *S. haematobium* infection and HIV in Sub-Saharan African countries found out that each *S. haematobium* infection per 100 individuals resulted in a 3% relative increase in HIV prevalence[20].

The primary causes of STH include *A. lumbricoides*, *T. trichiura* (ingestion of eggs from contaminated soil) and hookworms which are caused by larval penetration into the skin[21]. Mature worms can live for years and produce many eggs in 4-6 weeks. Depending on the environmental conditions, STH ova and larvae may survive in the soil for a couple of months[22]. STH infections are capable of causing harm to both bodily growth and development, mental activity, verbal and cognitive abilities[23]. Urinary schistosomiasis and geohelminths are health issues in the rural parts of Kwale County, Coastal Kenya. In June 2012, the study also found a significant rise in *Schistosoma* infection among school going children, from 15.4 to 29.9 percent, and this was after a six-month survey after deworming[24]. Adult infections are far less targeted compared to children[25]. Despite all possible consequences of these infections among women of reproductive age, this group has remained understudied and neglected in many endemic regions of the world, with most control programs focusing on school aged children. This study sought to assess the epidemiology of urinary schistosomiasis and soil-transmitted helminthiasis among women of reproductive age in Kwale County, Kenya.

2. Materials and methods

2.1. Study area

The study was conducted in Kwale County, in Coast Province. The County is located in Kenya's south-east corner, to the south

is Tanzania while Indian Ocean to the east (3.558°S-4.675°S, 38.452°E-39.663°E). The county has an area of 8 295 km^2 and a population of 866 820 people (Kenya National Bureau of Statistics, 2019). The county experiences an annual monsoon climate, which is hot and dry from January to April and coolest from June to August. The average temperature in the county is 24.2 ℃ which favours the high release of cercarial into the waters. The county has an annual rainfall ranging from 400 to 1 680 mm. Most inhabitants are subsistence farmers. Snails, the intermediate host of schistosomiasis, breed well in the arid regions, where there are many dams and seasonal streams, a case in Kwale County. Matuga sub-county which is among the five sub-counties in the Kwale County was the focus of the study. Sampling was done in four randomly selected villages from Mkongani ward, namely, Pengo, Mwele, Kibarani A and Kibarani B. The population in Matuga is approximately 194 250 people comprising of 95 831 and 98 419 males and females respectively. The sub-county covers a land area of approximately 1 032.4 square kilometres[26].

2.2. Study design and study population

The study was carried out from April 2022 to July 2022. A community-based cross-sectional study design was employed[27], in which urine and stool samples were collected and examined to determine the prevalence and intensity of urinary schistosomiasis and soil transmitted helminthiasis among women of reproductive age from the four selected villages. All women of reproductive age (15-<50) years constituted the study population and were regarded as the target group.

2.3. Sample size determination

The sample size was determined using Fishers formula for prevalence studies[28] by assuming the estimate prevalence of 45% found during a study[29] which was done by where prevalence of urinary schistosomiasis was found to range between 0 and 91.3% among school children.

$$N = \frac{Z^2 P (1-P)}{D^2}$$

Where N=minimum sample size, Z=Standard normal deviation 95% confidence interval (1.96), P=Estimated prevalence of schistosomiasis which is averaged at 45%, that is 0.45, D=Degree of precision (5%, that is 0.05). The sample size is therefore given as:

$$N = \frac{1.96^2 \times 0.45 (1-0.45)}{0.05^2}$$

$$N = \frac{3.8416 \times 0.2475}{0.0025}$$

$N = 380.3184$

10% Of non-response then $N = \frac{380}{0.9} = 422$

A total of 422 study subjects were chosen at random after being proportionally assigned to each village.

2.4. Inclusion and exclusion criteria

All female residents aged 15-<50 years were invited to participate in the study and those who consented were enrolled in the study. All below and above the age bracket and the pregnant women were excluded in the study.

2.5. Sample collection

Respondents were given two labelled stool and urine containers bearing the subjects' specific identification code and asked to fill them with approximately 4 g of stool and 30 mL of urine. Urine specimen was collected between 10:00 am and 2:00 pm, a convenient time for peak production of eggs by *S. haematobium*[29]. Stool and urine samples were kept separately in cool boxes and immediately transported to the Mkongani health centre laboratory for parasitological analysis.

2.6. Urine examination

The urine analysis was done using the filtration technique and the urine test strip (dipstick). Upon arrival at the laboratory, the urine samples were immediately tested for haematuria, proteinuria and leukocyturia using urine reagent strips.

Using the urine filtration process, ten millilitres (10 mL) of each individual's urine sample was filtered through a 12 micron-pore polycarbonate filter and analysed microscopically. Intensity of schistosomiasis infection was determined using mean egg loads and intensities classified as: light infection (1-49 eggs/10 mL of sample) and heavy infection (≥50 eggs/10 mL of sample).

2.7. Stool examination

Stool samples were analysed within 5 hours of collection from the participants. Each sample was processed using a double Kato-Katz technique[30]. Two microscope slides per stool were prepared using standard template. To obtain the number of eggs per gram, the counted eggs were multiplied using a standard conversion factor[24]. Hookworm infection was classified as light [(1-1 999 egg per gram (EPG)], moderate (2 000-3 999 EPG) and heavy (≥4 000 EPG). *T.*

trichiura infection classified as light (1-999 EPG), moderate (1 000-9 999 EPG) and heavy (≥1 000 EPG) while *A. lumbricoides* infection classified as light (1-4 999 EPG), moderate (5 000-49 999 EPG) and heavy (≥50 000 EPG) guidelines by the WHO[31].

2.8. Questionnaire

A pre-tested standardized questionnaire was provided to respondents in the study area to collect socio-demographic data and WASH practices. The questionnaire had unique identification codes to ensure consistency with the collected samples. Trained personnel verbally interviewed respondents and filled responses where applicable.

2.9. Quality control

Prior to data collection, the questionnaire and other materials were pretested. Laboratory examinations were performed under the supervision of experienced medical laboratory technologists.

2.10. Ethical consideration

Ethical clearance to carry out the research was sought from Kenyatta National Hospital Institutional review board (P453/06/2021). Permission to carry out the study in the community was obtained from Kwale County Department of Health REF NO: KWL/6/5/CEC/39/VOL.1/45.

2.11. Data management and analysis

The data was entered in Microsoft spreadsheet for analysis using SPSS statistical software, version 25.0. Descriptive statistics including frequency percentages, median and range was used to summarise demographic characteristics of the study participants. The proportion of infected individuals was calculated within the study participants. Intensity level was graded into light, moderate and heavy categories for STH whereas urinary schistosomiasis intensity was graded into light (1-49 eggs/10 mL) and heavy (≥50 eggs/10 mL). *Chi*-square (χ^2) was used to compare prevalence and sociodemographic characteristics such as age groups, education level and occupation whereas for variables whose expected frequencies were less than 5, Fisher's exact *Chi*-square was used. Due to the non-normality of eggs counts, the Kruskal-Wallis *H*-test was used to compare median egg loads of two or more groups such as education level. Bivariable logistic regression analysis was performed for the association of each WASH factor with the urinary schistosomiasis and soil-transmitted helminthiasis. Candidate variables for multivariable logistic regression were selected based on *P*-value

result during bivariable analysis (*P*≤0.25). *P*-values <0.05 were considered as statistically significant.

3. Results

3.1. Socio−demographic characteristics of the study participants

Four hundred and twenty-two participants were enrolled in the study accounting to 100% response rate. This was due to prior mobilisation of the study by Community Health Volunteers. The age of study participants ranged from 15 to 49 years. 236 (55.9%) Aged 15-<20 years. 260 (61.6%) Were not married while 161 (38.2%) were married. According to the level of education, 280 (66.4%) had attained primary level of education, 86 (20.4%) secondary education, 2 (0.5%) tertiary education while 54 (12.8%) had not attended any form of training. In terms of occupation, 244 (57.8%) were students while the rest were farmers 163 (38.6%), traders 12 (2.8%) and only 3 (0.7%) individuals had formal employment. Based on knowledge about urinary schistosomiasis and soil-transmitted helminthiasis, 275 (65.2%) had heard about urinary schistosomiasis and soil-transmitted helminthiasis, with 139 (32.9%) having no idea about urinary schistosomiasis and soil-transmitted helminthiasis. The main source of water for domestic use among the study participants was surface water 372 (88.2%) followed by standpipe 89 (21.1%), unprotected well 83 (19.7%) and borehole 39 (9.2%). Collecting water was the main reason for water contact among the study participants: 396 (93.8%) followed by crossing to go to a place 354 (83.9%), washing 347 (82.2%), bathing 88 (20.9%) and lastly swimming 3 (0.7%). 407 (96.4%) Have latrine in their home while 15 (3.6%) have no latrine at their homes (Table 1).

3.2. Prevalence of urinary schistosomiasis and soil−transmitted helminthiasis

Of the 422 participants who were tested for urinary schistosomiasis, 20 were positive giving an overall prevalence of 4.7% (95% *CI* 2.8%-6.9%). The prevalence of urinary schistosomiasis was higher in Pengo (6.5%) compared to Mwele, Kibarani B and Kibarani A with the prevalence of 5.7%, 4.8% and 1.9% respectively. There were no statistically significant differences observed in the prevalence of urinary schistosomiasis among the four villages (*F*=3.056, *P*=0.403). Based on the age groups, women aged 15-<20 years (15, 6.4%) had the highest prevalence, followed by 20-<30 years (3, 3.8%), 40-<50 years (2, 4.3%) whereas those aged 30-<40 years showed no infection. There was no significant difference in the prevalence of urinary schistosomiasis among the age groups (*F*=4.454,

P=0.196). Marital status, occupation, and knowledge about urinary schistosomiasis did not show statistically significant associations with urinary schistosomiasis prevalence. However, education level was significantly associated with urinary schistosomiasis prevalence (*F*=7.280, *P*=0.049), with women having no formal education exhibiting the highest prevalence (9.3%), followed by those with primary (4.3%) and secondary (3.5%) education, while no infections were observed among those with tertiary education.

Table 1. Sociodemographic characteristics of the participants (*n*=422).

Variable	No. of the examined, *n* (%)
Village	
Kibarani A	105 (24.9)
Kibarani B	105 (24.9)
Mwele	105 (24.9)
Pengo	107 (25.9)
Age groups, years	
15-<20	236 (55.9)
20-<30	80 (19.0)
30-<40	59 (14.0)
40-<50	47 (11.1)
Marital status	
Married	161 (38.2)
Not married	260 (61.6)
Divorced/separated	1 (0.2)
Level of education	
No formal education	54 (12.8)
Primary	280 (66.4)
Secondary	86 (20.4)
Tertiary	2 (0.5)
Occupation	
Student	244 (57.8)
Farmer	163 (38.6)
Trader	12 (2.8)
Employed	3 (0.7)
Aware of disease	
No idea	139 (32.9)
Heard	275 (65.2)
Know	8 (1.9)
Reason for water contact	
Crossing to place	354 (83.9)
Collecting water	396 (93.8)
Bathing	88 (20.9)
Washing	347 (82.2)
Swimming	3 (0.7)
Have latrine	
No	15 (3.6)
Yes	407 (96.4)
Source of water	
Surface water	
No	50 (11.9)
Yes	372 (88.2)
Standpipe water	
No	333 (79.1)
Yes	89 (21.1)
Borehole	
No	383 (90.7)
Yes	39 (9.2)
Unprotected well	
No	339 (80.3)
Yes	83 (19.7)

The overall prevalence of STH infection was 4.5% (19/422, 95% *CI* 2.6%-6.7%) with the hookworms (3.6%, 95% *CI* 1.9%-5.5%) being the main species, followed by *T. trichiura* (0.9%, 95% *CI* 0.01%-1.90%), whereas *A. lumbricoides* showed no infection. Based on the villages, Kibarani A showed a slightly high prevalence of hookworms (5.7%, 6/422) followed by Mwele (3.8%), Kibarani B (2.9%) and Pengo (1.9%). There was no statistically significant difference in the prevalence of STH between the various sociodemographic characteristics except for *T. trichiura* that showed a significant difference between its prevalence and knowledge about the disease (*F*=7.321, *P*=0.032).

No multiple infections of *S. haematobium* and soil-transmitted helminths were observed (Table 2).

3.3. Prevalence of haematuria, proteinuria and leukocyturia

Table 3 represents the prevalence of three key urinary symptoms (haematuria, proteinuria, and leukocyturia) and their association with *S. haematobium* infection. Overall, 29 (6.9%) individuals had haematuria, 37 (8.8%) had proteinuria while 29 (6.9%) had leukocyturia. This study revealed statistically significant associations between *S. haematobium* infection and haematuria, proteinuria, leukocyturia (Table 3).

3.4. Infection intensity of urinary schistosomiasis and STH among women of reproductive age

The intensity of urinary schistosomiasis among the research participants ranged from 1 to 120 eggs/10 mL of urine with a median total egg count of 18.45 eggs/10 mL. Based on the WHO categorization of *S. haematobium* infection intensities, 18 (4.3%) had light infection intensities (1-49 eggs/10 mL), while 2 (0.5%) individuals had heavy infection intensities (≥50 eggs/10 mL of urine). The parasite median egg load was high in Kibarani B (20.00 eggs/10 mL, 95% *CI* 1.00-120.00) compared to Mwele (13.50 eggs/10 mL, 95% *CI* 1.00- 25.50), Pengo (9.00 eggs/10 mL, 95% *CI* 5.00-17.00) and Kibarani A (3.50 eggs/10 mL, 95% *CI* 1.00- 6.00), though there were no significant differences observed (*P*=0.390). In terms of the age groups, those aged 20-<30 years had slightly higher median infection intensities (20.00 eggs/10 mL, 95% *CI* 15.00-60.00) compared to other age groups but the differences were also not statistically significant (*P*=0.079). In summary, there was no significant differences in median egg counts across villages (*P*=0.390), age groups (*P*=0.079), education level (*P*=0.703), occupation (*P*=0.741), marital status (*P*=0.606) and knowledge about urinary schistosomiasis (*P*=0.283) (Table 4).

Table 2. Prevalence of urinary schistosomiasis and soil-transmitted helminth in relation to sociodemographic characteristics [n (%)].

Categories	Infected with *S. haematobium*	*P* value	Infected with hookworm	*P* value	Infected with *T. trichiura*	*P* value
Overall	20 (4.7)		15 (3.6)		4 (0.9)	
Village		0. 403		0.450		0.761
Kibarani A	2 (1.9)		6 (5.7)		0 (0.0)	
Kibarani B	5 (4.8)		3 (2.9)		1 (1.0)	
Mwele	6 (5.7)		4 (3.8)		2 (1.9)	
Pengo	7 (6.5)		2 (1.9)		1 (0.9)	
Age groups, years		0.196		0.235		0.099
15-<20	15 (6.4)		7 (3.0)		1 (0.4)	
20-<30	3 (3.8)		2 (2.5)		1 (1.3)	
30-<40	0 (0.0)		5 (8.5)		0 (0.0)	
40-<50	2 (4.3)		1 (2.1)		2 (4.3)	
Marital status		0.282		0.605		0.642
Married	5 (3.1)		7 (4.3)		2 (1.2)	
Not married	15 (5.8)		8 (3.1)		2 (0.8)	
Divorced/separated	0 (0.0)		0 (0.0)		0 (0.0)	
Level of education		0.049[*]		0.174		0.861
No formal education	5 (9.3)		2 (3.7)		0 (0.0)	
Primary	12 (4.3)		10 (3.6)		3 (1.1)	
Secondary	3 (3.5)		3 (3.5)		1 (1.2)	
Tertiary	0 (0.0)		0 (0.0)		0 (0.9)	
Occupation		0.639		0.526		0.710
Student	14 (5.7)		8 (3.3)		2 (0.8)	
Farmer	6 (3.7)		6 (3.7)		2 (1.2)	
Trader	0 (0.0)		1 (8.3)		0 (0.0)	
Employed	0 (0.0)		0 (0.0)		0 (0.0)	
Aware of disease		0.808		0.837		0.032[*]
No idea	7 (5.0)		4 (2.9)		2 (1.4)	
Heard	13 (4.7)		11 (4.0)		1 (0.4)	
Know	0 (0.0)		0 (0.0)		1 (12.5)	

[*]Significant variables at 5% significance level.

The overall geometric mean egg per gram (EPG) for STH was 56.16 egg/gram and 48.48 egg/gram for *T. trichiura* and hookworms, respectively. *A. lumbricoides* showed no infection. The intensities of hookworms ranged from 24 to 960 EPG while those of *T. trichiura* ranged from 24 to 144 EPG. In accordance with the WHO classification of STH infection intensities, all intensities were light with no moderate and heavy infection intensities observed.

Table 3. Prevalence of haematuria, proteinuria, and leukocyturia in relation to *S. haematobium* infection.

Categories	Overall, n (%)	No. of *S. haematobium* infection	*P* value
Haematuria			
No	393 (93.1)	0	<0.001
Yes	29 (6.9)	20	
Proteinuria			
No	385 (91.2)	0	<0.001
Yes	37 (8.8)	20	
Leukocyturia			
No	393 (93.1)	7	<0.001
Yes	29 (6.9)	13	

3.5. *WASH factors associated with urinary schistosomiasis and soil−transmitted helminthiasis*

In the bivariable logistic regression, $P\leq0.25$ was used for the selection of variables in the multivariable analysis. The multivariable analysis of WASH factors associated with urinary schistosomiasis revealed the groups associated with high odds of infection. Women without access to latrine showed increased risk of urinary schistosomiasis (a*OR* 15.7, 95% *CI* 4.2-58.5, *P*<0.001) compared to those with latrines. Women using surface water as source of water (a*OR* 1.0, 95% *CI* 0.2-1.4, *P*=0.010) showed increased risk of getting urinary schistosomiasis. Women who crossed the river to go to a place (a*OR* 1.1, 95% *CI* 0.3-1.6, *P*=0.009) also showed increased risk of getting urinary schistosomiasis. On the contrary, use of stand pipe as the source of water (a*OR* 0.0, 95% *CI* 0.0-0.3, *P*=0.006) showed reduced risk of being infected with *S. haematobium*. Lack of latrine, surface water and crossing the river to go to a place were statistically significant risk factors associated with infection with *S. haematobium*. Use of stand piped water was found to be protective against urinary schistosomiasis (Table 5).

In bivariable regression analysis, defecating around the water source (*OR* 4.3, 95% *CI* 1.5-12.9) had a statistically significant association with the prevalence of STHs (*P*=0.008). However, this did not significantly predict STH infection by women of reproductive age in multivariable logistic regression. Collecting water as a reason for water contact (a*OR* 0.2, 95% *CI* 0.0-1.0) was statistically and independently associated with reduced risk of STHs infection (*P*=0.045) (Table 6).

Table 4. Association between the intensity of *S. haematobium* and sociodemographic characteristics.

Category	No. of infection	Intensity of infection		Median egg count (95% *CI*)	*P* value
		Light, *n* (%)	Heavy, *n* (%)		
Overall median urinary schistosomiasis	20	18 (4.3)	2 (0.5)	18.45 (9.15-31.40)	
Village					0.390
Kibarani A	2	2 (1.9)	0 (0.0)	3.50 (1.00- 6.00)	
Kibarani B	5	3 (2.9)	2 (1.9)	20.00 (1.00-120.00)	
Mwele	6	6 (5.7)	0 (0.0)	13.50 (1.00-25.50)	
Pengo	7	7 (6.5)	0 (0.0)	9.00 (5.00-17.00)	
Age group, years					0.079
15-<20	15	14 (5.9)	1 (0.4)	9.00 (3.00-18.50)	
20-<30	3	2 (2.5)	1 (1.3)	20.00 (15.00- 60.00)	
40-<50	2	2 (4.3)	0 (0.0)	7.50 (6.00-9.00)	
Marital status					0.606
Married	5	5 (3.1)	0 (0.0)	9.00 (1.00-29.00)	
Not married	15	13 (5.0)	2 (0.8)	10.00 (4.50-20.00)	
Level of education					0.703
No formal education	5	5 (9.3)	0 (0.0)	15.00 (6.00-29.00)	
Primary	12	11 (3.9)	1 (0.4)	7.50 (3.00-17.00)	
Secondary	3	2 (2.3)	1 (1.2)	20.00 (1.00-60.00)	
Occupation					0.741
Student	14	12 (4.9)	2 (0.8)	9.50 (3.00-20.00)	
Farmer	6	6 (3.7)	0 (0.0)	12.00 (3.50-28.91)	
Aware of disease					0.283
No idea	7	6 (4.3)	1 (0.7)	15.00 (6.00-67.42)	
Heard	13	12 (4.4)	1 (0.4)	9.00 (3.00-17.00)	

4. Discussion

Schistosomiasis and soil-transmitted helminthiasis remain a major public health issue in many developing nations among rural populations in Sub-Saharan Africa, Kenya included. The current study sought to assess the epidemiology of urinary schistosomiasis and soil-transmitted helminthiasis among women of reproductive age in Mwaluphamba, Kwale County, Kenya. The overall prevalence for urinary schistosomiasis and soil-transmitted helminthiasis among the women of reproductive age based on the sampled villages was 4.7% and 4.5%, respectively. Thus, out of the three species of STH, hookworm was the dominant followed by *T. trichiura* whereas this study found no infections as a result of *A. lumbricoides*.

The prevalence of urinary schistosomiasis was lower compared to a study done among people of different ages[15]. The study revealed high proportions of *S. haematobium* among the participants in the catchment areas of Mwachinga, Mwaluphamba and Bilashaka Dispensaries with 11.96%, 20.96% and 22.13% prevalence of infected individuals respectively, though the catchment area of Mbuwani dispensary showed a lower prevalence of 1.13% when compared to our study. The prevalence of urinary schistosomiasis and STH in this study was also lower compared to a study conducted in selected schools in this county, where the prevalence of *S. haematobium*, hookworm and *T. trichiura* among school going children was found to be 33.2%, 26.1% and 1.6% respectively[32]. A study done from four randomly selected villages of Bilashaka, Mwaluphamba, Mwachinga, and Dumbule reported a prevalence of 5.6% for STH, which was slightly above the STH prevalence reported during our study[7].

A study done in Mwaluphamba, Kwale County in 2011 reported a high prevalence of hookworm (41.7%) among adults[33]. Since this study was done a long time ago, the drastic reduction for hookworms infection among the adults observed recently could be attributed to possible improved sanitation, health education and behavioural change coupled with improved use of toilets and water[7]. Possible explanations for the reduced prevalence observed in the current study compared to earlier studies could be attributed to seasonality in schistosomiasis transmission and differences in geographical locations. The current investigation was conducted during the rainy season, which may account for the reduced prevalence observed. This is consistent to a study carried out in Southern Mauritania that showed significantly higher schistosomiasis infections during dry season as compared to rainy season[34]. Low prevalence in this study could also be attributed to both school based and community based Mass Drug Administration which is usually done once every year[15].

High prevalence of urinary schistosomiasis was noted among the women aged between 15-<20 years compared to the other age groups, which agreed with the previously conducted studies in Cameroon[35,36]. This may be because they are the most physically active age group and engage in the majority of outdoor activities, including swimming in contaminated water and obtaining water from rivers. This study found that surface water was the main source of water in the sampled villages hence high risk of exposure. The prevalence of hookworms and *T. trichiura* was found to be high in

Table 5. Bivariable and multivariable logistic regression for WASH factors associated with urinary schistosomiasis.

Factor	OR (95% CI)	P-value	aOR (95% CI)	P-value
Age group, years				
15-<20	1			
20-<30	0.6 (0.2-2.0)	0.390	-	-
40-<50	0.7 (0.1-3.0)	0.583	-	-
Wash hands				
After defecation				
No	1			
Yes	0.6 (0.2-1.5)	0.289	-	-
After urination				
No	1			
Yes	1.9 (0.2-15.3)	0.558	-	-
Before eating				
No	1			
Yes	0.7 (0.3-2.0)	0.536	-	-
Hands noticeably dirty				
No	1			
Yes	1.9 (0.4-8.2)	0.410	-	-
What used to wash hands				
Soap and water	1		1	
Water only	2.0 (0.8-4.9)	0.148	1.3 (0.4-4.0)	0.624
Availability of latrine				
No	13.1 (4.0-43.0)	<0.001*	15.7 (4.2-58.5)	<0.001*
Yes	1		1	
Source of water				
Surface water				
No	1		1	
Yes	1.4 (0.1-2.1)	0.079	1.0 (0.2-1.4)	0.010*
Borehole				
No	1			
Yes	1.7 (0.5-6.2)	0.393	-	-
Unprotected well				
No	1			
Yes	1.8 (0.7-4.9)	0.240	-	-
Stand pipe				
No	1		1	
Yes	0.2 (0.0-1.4)	0.102	0.0 (0.0-0.3)	0.006*
Reason for water contact				
Crossing river				
No	1		1	
Yes	1.4 (0.2-2.1)	0.085	1.1 (0.3-1.6)	0.009*
Bathing				
No	1			
Yes	1.7 (0.6-4.5)	0.307	-	-
Collecting water				
No	1		1	
Yes	0.3 (0.1-1.2)	0.093	1.2 (0.1-12.4)	0.891
Washing clothes				
No	1			
Yes	0.9 (0.3-2.6)	0.790	-	-
Urinate in above events				
In the nearby bush	1		1	
Around water source	0.3 (0.1-1.3)	0.107	0.7 (0.1-5.0)	0.713
Defecate in above events				
In the nearby bush	1			
Around water source	1.3 (0.3-5.8)	0.740	-	-

*Significant variables at 5% significance level; OR=odds ratio; 95% CI=95% confidence interval; WASH: water, sanitation, and hygiene; -: variables not included in multivariable logistic regression (P>0.25).

the age groups 30-<40 years and 40-<50 years, respectively. This was not consistent with the observation by Jeza et al.[7], in which the prevalence of STH decreases with age since our study found a variation of prevalence among the age groups. One possible explanation is regional or geographic differences in the prevalence of STH infections. Different areas may have varying levels of sanitation, hygiene practices, and exposure to contaminated soil, which can influence the transmission of these parasites.

Table 6. Bivariable and multivariable logistic regression for WASH factors associated with soil-transmitted helminthiasis.

Factor	OR (95% CI)	P-value	aOR (95% CI)	P-value
Age group, years				
15-<20	1		1	
20-<30	1.1 (0.3-4.3)	0.879	1.0 (0.3-4.0)	0.991
30-<40	2.6 (0.8-8.4)	0.100	2.8 (0.8-9.3)	0.099
40-<50	1.9 (0.5-7.6)	0.340	1.6 (0.4-6.6)	0.513
Wash hands				
After defecation				
No	1			
Yes	0.7 (0.3-1.7)	0.426	-	-
Before eating				
No	1			
Yes	1.0 (0.4-2.7)	0.977	-	-
Hands noticeably dirty				
No	1			
Yes	0.7 (0.2-2.3)	0.615	-	-
What used to wash hands				
Soap and water	1			
Water only	1.1 (0.5-2.9)	0.768	-	-
Source of water				
Surface water				
No	1		1	
Yes	0.4 (0.1-1.0)	0.061	3.0 (0.1-85.2)	0.516
Borehole				
No	1		1	
Yes	2.7 (0.9-8.6)	0.090	1.3 (0.0-1.0)	0.821
Unprotected well				
No	1			
Yes	0.5 (0.1-2.1)	0.316	-	-
Stand pipe				
No	1			
Yes	1.8 (0.6-4.7)	0.270	-	-
Reason for water contact				
Crossing river				
No	1			
Yes	1.6 (0.4-7.2)	0.518	-	-
Bathing				
No	1		1	
Yes	0.2 (0.0-1.5)	0.122	0.2 (0.0-1.6)	0.136
Collecting water				
No	1		1	
Yes	0.2 (0.1-0.7)	0.009[*]	0.2 (0.0-1.0)	0.045[*]
Washing clothes				
No	1			
Yes	0.6 (0.2-1.7)	0.324	-	-
Urinate in above events				
In the nearby bush	1			
Around water source	1.3 (0.2-9.9)	0.820	-	-
Defecate in above events				
In the nearby bush	1		1	
Around water source	4.3 (1.5-12.9)	0.008[*]	4.2 (0.5-35.6)	0.189

[*]Significant variables at 5% significance level; *OR*=odds ratio; 95% *CI*=95% confidence interval; WASH: water, sanitation, and hygiene; -: variables not included in multivariable logistic regression (*P*>0.25).

The significant association observed between education level and urinary schistosomiasis prevalence in this study, with the highest prevalence among women with no formal education aligns with findings from several previous studies. For instance, a study by M'Bra *et al.* reported comparable results, indicating a higher prevalence of schistosomiasis among individuals with lower educational attainment[37]. This pattern could be attributed to several interconnected factors. Firstly, individuals with lower levels of education may have limited access to health education and awareness campaigns, reducing their knowledge about schistosomiasis transmission and prevention. Additionally, lower-educated individuals may be more likely to engage in activities that expose them to contaminated water sources, such as agricultural work or domestic chores, further increasing their risk of infection.

Out of 29 women of reproductive age positive for haematuria, 20 (69.0%) had *S. haematobium* eggs in their urine. Not all cases of haematuria tested positive for *Schistosoma* eggs, and this outcome is consistent with earlier investigations[38]. Some cases of haematuria reported in this study were as a result of menstrual blood from some study participants. Of the 37 women that were positive for proteinuria, 20 (54.1%) had *S. haematobium* eggs in their urine. The statistical significance between *S. haematobium* and haematuria, proteinuria, leukocyturia implies that these symptoms may serve as diagnostic signs of *Schistosoma* infection. A similar result was reported in Senegal[39] and Ghana[40].

The morbidity of urinary schistosomiasis is linked to the intensity of the infection[41]. The study participants' infection intensities of urinary schistosomiasis ranged from 1 to 120 eggs/10 mL of urine, with an overall median egg count of 18.45 eggs/10 mL. Based on the WHO categorization of *S. haematobium* infection intensities, the overall intensity of *S. haematobium* in this study was under light infection category, although 2 (0.5%) individuals had heavy infection intensities (≥50 eggs/10 mL of urine). The median egg count in this study was slightly lower than in a study conducted among women of reproductive age in Tanzania, which revealed a range of 8 to 38 eggs/10 mL of urine with an overall geometric mean of 19.5 eggs/10 mL of urine[42]. The median egg count in this study is also considerably lower than that reported in a study carried out in Kwara state, Nigeria, where the mean egg count was 127.9 eggs/10 mL of urine[43]. The differences in urinary schistosomiasis infection intensity between the studied regions can be primarily attributed to geographical variations in transmission dynamics and local water contact behaviours. Additionally, variations in the implementation and effectiveness of schistosomiasis control programs and the age distribution of the populations studied may contribute to differences in infection intensity. All cases of soil-transmitted helminthiasis among women of reproductive age in this study were light infection. This is consistent to a study done among school children in Gurage zone southern Ethiopia (January to December 30, 2017), where all cases of the soil transmitted helminthes infection were with light infection, such as hookworm, *Enterobius vermicularis*, *Taenia* species, *A. lumbricoides*, *T. trichiura* and *Hymenolepis nana*[44].

Analysis of WASH related factors show that women without latrines had higher risk of urinary schistosomiasis infection than those with a latrine. This is in accordance with a study by Sady *et al*[45], which reported that lack of a latrine in the house was significantly associated with the prevalence of urinary schistosomiasis. Individuals lacking latrines in their house might have a tendency of defecating or urinating near water bodies, therefore increasing the risk of schistosome transmission. The statistically significant associations between reliance on surface water sources, and the practice of crossing rivers and *S. haematobium* infection align with findings from previous studies. For instance, a study by Mutsaka-Makuvaza *et al*. conducted in semi-arid areas of Makonde rural district, Zimbabwe, reported similar results, highlighting that the dependence on potentially contaminated surface water bodies were key risk factors for *S. haematobium* infection. This consistency in findings can be attributed to the fact that *S. haematobium* transmission primarily occurs through contact with infested freshwater sources. These findings underscore the critical importance of sanitation infrastructure and access to safe water sources in preventing *S. haematobium* infection in endemic areas[46].

Use of stand pipe as the source of water was found to be protective against urinary schistosomiasis since individuals using stand pipe had reduced risk of infection. A similar finding was observed by Balen *et al*[47], who found that the spread of urinary schistosomiasis is positively correlated with not using a tap as a source of drinking water. This is also consistent to a study conducted in Yemen, which found that children who used unsafe sources for drinking water had significantly higher risk of having schistosomiasis when compared to those living in houses supplied with piped water[45]. Stand pipe minimises water contact with the cercarial infested water bodies hence reducing the risk of *Schistosoma* infection.

Collecting water as a reason for water contact had reduced risk of infection by soil-transmitted helminthiasis. This is in accordance to a systematic review and meta-analysis study which was conducted to examine the associations of improved WASH on infection with STH. The study reported that water-related access and practices were generally associated with lower risk of STH infection[48]. Similar to this study, another study finding indicated that better water, sanitation and hygiene (WASH) practice has a significant reduction in the prevalence of STH, especially *A. lumbricoides* and hookworm[49]. The reduced risk of infection with collecting water in this study could be attributed to the fact that some people used stand pipes and boreholes which are less likely to be contaminated by soil-transmitted helminths.

Defecating around the water source had a statistically significant association with the prevalence of soil-transmitted helminthiasis. This is consistent to a study done in the Tiko Health District, South West Region of Cameroon, which revealed that open defecation is a risk factor for STH infections[50]. This is because open defecation is suitable for parasite distribution which maximizes parasite transmission. After adjusting for the effects of confounders, the study found that use of surface water showed high risk for soil-transmitted helminthiasis infection, though this was not statistically significant. Similarly, Campbell *et al*.[51] found few consistent associations between access to safe water sources and STH infections in their multivariable analyses. Such inconsistencies might be attributed to the indirect nature of STH transmission through water.

The study had some limitations: the urine and stool samples were

collected during rainy season, which might have underestimated the prevalence of urinary schistosomiasis and soil-transmitted helminthiasis, respectively.

In conclusion, the present study has given an insight on the prevalence and intensity of urinary schistosomiasis and soil-transmitted helminthiasis in Mwaluphamba location that form the basis for strengthening control and elimination programmes for these neglected tropical diseases. Notably, the study identified several risk factors for these infections, including the absence of latrines, reliance on surface water sources, and practices such as crossing rivers, underscoring the importance of improved sanitation infrastructure and access to safe water sources in preventive efforts. Hence, our suggestion to policymakers and relevant stakeholders is to promote the integration of deworming efforts with initiatives focused on improving water quality, hygiene, and sanitation.

Conflicts of interest statement

The authors declare that there is no conflict of interest regarding the publication of this article.

Funding

Acknowledgments

Authors' contributions

S.M.N. designed the study and conducted data gathering and laboratory analysis. All authors analysed and interpreted the results. S.M.N. drafted the manuscript. J.N., J.M.M. and J.R. critically revised the manuscript. All authors contributed to the final version of the manuscript.

References

[1] Sacolo-Gwebu H, Chimbari M, Kalinda C. Prevalence and risk factors of schistosomiasis and soil-transmitted helminthiases among preschool aged children (1-5 years) in rural KwaZulu-Natal, South Africa: A cross-sectional study. *Infect Dis Poverty* 2019; **8**(1):1-12.

[2] Nisha M, Aiman M, Asyhira N, Syafiq H, Atiqah N, Kumarasamy V, et al. Risk factors associated with soil transmitted helminth (STH) infection in two indigenous communities in Malaysia. *Trop Biomed* 2020; **37**(2): 379-388.

[3] Fatimah A, Emmanuel B, Idiat B, Paul A. Review article impact of human schistosomiasis in sub-Saharan Africa. *Brazilian J Infect Dis* 2015; **19**(2): 196-205.

[4] Hajissa K, Muhajir AEMA, Eshag HA, Alfadel A, Nahied E, Dahab R, et al. Prevalence of schistosomiasis and associated risk factors among school children in Um-Asher Area, Khartoum, Sudan. *BMC Res Notes* 2018; **11**(1): 1-5.

[5] Amuga GA, Nebe OJ, Nduka FO, Njepuome N, Dakul DA, Isiyaku S, et al. Schistosomiasis: Epidemiological factors enhancing transmission in Nigeria. *Glob Res J Public Health Epidemiol* 2020; **8**(7): 23-32.

[6] Beyene M. *Prevalence and intensity of intestinal parasitic infections of school children in Ahmed Gurey Primary School, Jigjiga Town, Somali Regional State, Ethiopia.* Doctoral thesis. Haramaya University; 2019.

[7] Jeza VT, Mutuku F, Kaduka L, Mwandawiro C, Masaku J, Okoyo C, et al. Schistosomiasis, soil transmitted helminthiasis, and malaria co-infections among women of reproductive age in rural communities of Kwale County, coastal Kenya. *BMC Public Health* 2022; **22**(1): 1-15.

[8] Omuok DA. *A malacology survey to map out schistosomiasis transmission sites on Mageta Island, Siaya county, Western Kenya.* Doctoral thesis. University of Nairobi; 2022.

[9] MOH-Kenya. *The 2nd Kenya National Strategic Plan for control of neglected tropical diseases 2016–2020.* Ministry of Health Kenya; 2016.

[10]Okoyo C, Campbell SJ, Owaga C, Onyango N, Medley G, Mwandawiro C. Statistical regression model of water, sanitation, and hygiene; treatment coverage; and environmental influences on school-level soil-transmitted helminths and schistosome prevalence in Kenya: Secondary analysis of the national deworming program data. *Am J Trop Med Hyg* 2021; **104**(6): 2251.

[11]Mwandawiro C, Okoyo C, Kihara J, Simiyu E, Kepha S, Campbell SJ, et al. Results of a national school-based deworming programme on soil-transmitted helminths infections and schistosomiasis in Kenya: 2012-2017. *Parasit Vectors* 2019; **12**(1): 1-18.

[12]Nikolay B, Mwandawiro CS, Kihara JH, Okoyo C, Cano J, Mwanje MT, et al. Understanding heterogeneity in the impact of national neglected tropical disease control programmes: Evidence from school-based deworming in Kenya. *PLoS Negl Trop Dis* 2015; **9**(9): e0004108.

[13]Strunz EC, Addiss DG, Stocks ME, Ogden S, Utzinger J, Freeman MC. Water, sanitation, hygiene, and soil-transmitted helminth infection: A systematic review and meta-analysis. *PLoS Med* 2014; **11**(3): e1001620.

[14]Mutuku FM, King CH, Bustinduy AL, Mungai PL, Muchiri EM, Kitron U. Impact of drought on the spatial pattern of transmission of *Schistosoma*

haematobium in coastal Kenya. *Am J Trop Med Hyg* 2011; **85**(6): 1065-1070.

[15]Kaiglová A, Changoma MJS, Špajdelová J, Jakubcová D, Bírová K. Urinary schistosomosis in patients of rural medical health centers in Kwale county, Kenya. *J Helminthol* 2020; **57**(1): 19-27.

[16]Holmen S. *Computer image analysis as a diagnostic tool in female genital schistosomiasis*. Doctoral thesis. Oslo University Hospital; 2016.

[17]Sturt AS, Webb EL, Francis SC, Hayes RJ, Bustinduy AL. Beyond the barrier: Female genital schistosomiasis as a potential risk factor for HIV-1 acquisition. *Acta Trop* 2020; **209**(April): 105524.

[18]Kukula VA, MacPherson EE, Tsey IH, Stothard JR, Theobald S, Gyapong M. A major hurdle in the elimination of urogenital schistosomiasis revealed: Identifying key gaps in knowledge and understanding of female genital schistosomiasis within communities and local health workers. *PLoS Negl Trop Dis* 2018; **13**(3): 1-14.

[19]Hotez PJ, Harrison W, Fenwick A, Bustinduy AL, Ducker C, Mbabazi PS, et al. Female genital schistosomiasis and HIV/AIDS: Reversing the neglect of girls and women. *PLoS Negl Trop Dis* 2019; **13**(4): 8-12.

[20]Ndeffo Mbah ML, Poolman EM, Drain PK, Coffee MP, van der Werf MJ, Galvani AP. HIV and *Schistosoma haematobium* prevalences correlate in sub-Saharan Africa. *Trop Med Int Heal* 2013; **18**(10): 1174-1179.

[21]World Health Organization. *Helminth control in school−age children. a guide for managers of control programmes*. Geneva: World Health Organization; 2011.

[22]Brooker S, Clements ACA, Bundy DAP. Global epidemiology, ecology and control of soil-transmitted helminth infections. *Adv Parasitol* 2006; **62**(6): 221-261.

[23]Bajiro M, Gedamu S, Hamba N. Prevalence, intensity of infection and associated risk factors for *Schistosoma mansoni* and soil transmitted helminthes among two primary school children at nearby rivers in Jimma town, South West. *Ann Clin Pathol* 2018; **6**(4): 1-8.

[24]Njenga SM, Mutungi FM, Wamae CN, Mwanje MT, Njiru KK, Bockarie MJ. Once a year school-based deworming with praziquantel and albendazole combination may not be adequate for control of urogenital schistosomiasis and hookworm infection in Matuga District, Kwale county, Kenya. *Parasit Vectors* 2014; **7**(1): 1-9.

[25]Crompton DWT, Nesheim MC. Nutritional impact of intestinal helminthiasis during the human life cycle. *Annu Rev Nutr* 2002; **22**: 35-59.

[26]Kenya National Bureau of Statistics. *Kenya population and housing census volume 1: Population by county and sub−county. 2019*. [Online]. Available from: https://www.knbs.or.ke/?wpdmpro=2019-kenya-population-and-housing-census-volume-i-population-by-county-and-sub-county. [Accessed on 10 November 2023].

[27]Tembo S. *Prevalence, intensity and factors associated with soil transmitted helminths infcetion among children in Chililabombwe District, Copperbelt Province, Zambia−cross sectional study*. Doctoral thesis. University of Zambia; 2019.

[28]Fisher LD. Self-designing clinical trials. *Stat Med* 1998; **17**: 1551-1562.

[29]Kihara J, Mwandawiro C, Waweru B, Gitonga CW, Brooker S. Preparing for national school-based deworming in Kenya: The validation and large-scale distribution of school questionnaires with urinary schistosomiasis. *Trop Med Int Heal* 2011; **16**(10): 1326-1333.

[30]Katz N, Chaves A, Pellegrino J. A simple device for quantitative stool thick-smear technique in *Schistosomiasis mansoni*. *Rev Inst Med Trop Sao Paulo* 1972; **14**(6): 397-400.

[31]World Health Organization. *Prevention and control of schistosomiasis and soil−transmitted helminthiasis*. Geneva: Report of WHO expert committee; 1998.

[32]Chadeka EA, Nagi S, Sunahara T, Cheruiyot NB, Bahati F, Ozeki Y, et al. Spatial distribution and risk factors of *Schistosoma haematobium* and hookworm infections among schoolchildren in Kwale, Kenya. *PLoS Negl Trop Dis* 2017; **11**(9): 1-17.

[33]Njenga SM, Mwandawiro CS, Muniu E, Mwanje MT, Haji FM, Bockarie MJ. Adult population as potential reservoir of NTD infections in rural villages of Kwale district, Coastal Kenya: Implications for preventive chemotherapy interventions policy. *Parasit Vectors* 2011; **4**(1): 2-7.

[34]Gbalégba NGC, Silué KD, Ba O, Ba H, Tian-Bi NTY, Yapi GY, et al. Prevalence and seasonal transmission of *Schistosoma haematobium* infection among school-aged children in Kaedi town, southern Mauritania. *Parasit Vectors* 2017; **10**(1): 1-12.

[35]Behnke JM, Gilbert FS, Southgate VR, Vercruysse J. Polyparasitism with *Schistosoma haematobium* and soil-transmitted helminth infections among school children in Loum, Cameroon. *Trop Med Int Heal* 2003; **8**(11): 975-986.

[36]Ntonifor HN, Mbunkur GN, Ndaleh NW. Epidemiological survey of urinary schistosomiasis in some primary schools in a new focus behind mount Cameroon, south west region, Cameroon. *East Afr Med J* 2012; **89**(3): 82-88.

[37]M'Bra RK, Kone B, Yapi YG, Silué KD, Sy I, Vienneau D, et al. Risk factors for schistosomiasis in an urban area in northern Côte d'Ivoire. *Infect Dis Poverty* 2018; **7**: 1-12.

[38]Opara KN, Wilson EU, Yaro CA, Alkazmi L, Udoidung NI, Chikezie FM, et al. Prevalence, risk factors, and coinfection of urogenital schistosomiasis and soil-transmitted helminthiasis among primary school children in Biase, Southern Nigeria. *J Parasitol Res* 2021; **2021**: 12.

[39]Meurs L, Mbow M, Boon N, van den Broeck F, Vereecken K, Dièye TN, et al. Micro-geographical heterogeneity in *Schistosoma mansoni* and *S. haematobium* infection and morbidity in a co-endemic community in Northern Senegal. *PLoS Negl Trop Dis* 2013; **7**(12): e2608.

[40]Boye A, Agbemator V, Mate-Siakwa P, Essien- Baidoo S. *Schistosoma* haematobium co-infection with soil-transmitted helminthes: Prevalence and risk factors from two communities in the central region of Ghana. *Int J Med Biomed Res* 2016; **5**(2): 86-100.

[41]Ojo JA, Adedokun SA, Akindele AA, Olorunfemi AB, Otutu OA, Ojurongbe TA, et al. Prevalence of urogenital and intestinal

schistosomiasis among school children in South-west Nigeria. *PLoS Negl Trop Dis* 2021; **15**(7): e0009628.

[42]Rite EE, Ng'weshemi Kapalata S, Munisi DZ. Prevalence, intensity, and factors associated with urogenital schistosomiasis among women of reproductive age in Mbogwe District Council, Geita region, Tanzania. *Biomed Res Int* 2020; **2020**: 6-12.

[43]Abdulkareem BO, Habeeb KO, Kazeem A, Adam AO, Samuel UU. Urogenital schistosomiasis among school children and the associated risk factors in selected rural communities of Kwara State, Nigeria. *J Trop Med* 2018; **2018**: 1-6. https://doi.org/10.1155/2018/6913918.

[44]Weldesenbet H, Worku A, Shumbej T. Prevalence, infection intensity and associated factors of soil transmitted helminths among primary school children in Gurage zone, South Central Ethiopia: A cross-sectional study design. *BMC Res Notes* 2019; **12**(1): 10-15.

[45]Sady H, Al-Mekhlafi HM, Mahdy MAK, Lim YAL, Mahmud R, Surin J. Prevalence and associated factors of schistosomiasis among children in Yemen: Implications for an effective control programme. *PLoS Negl Trop Dis* 2013; **7**(8): e2377.

[46]Mutsaka-Makuvaza MJ, Matsena-Zingoni Z, Katsidzira A, Tshuma C, Chin'ombe N, Zhou XN, et al. Urogenital schistosomiasis and risk factors of infection in mothers and preschool children in an endemic district in Zimbabwe. *Parasit Vectors* 2019; **12**: 1-15.

[47]Balen J, Raso G, Li YS, Zhao ZY, Yuan LP, Williams GM, et al. Risk factors for helminth infections in a rural and a peri-urban setting of the Dongting Lake area, People's Republic of China. *Int J Parasitol* 2011; **41**(11): 1165-1173.

[48]Strunz EC, Addiss DG, Stocks ME, Ogden S, Utzinger J, Freeman MC. Water, sanitation, hygiene, and soil-transmitted helminth infection: A systematic review and meta-analysis. *PLoS Med* 2014; **11**(3): 10.

[49]Grimes JET, Tadesse G, Mekete K, Wuletaw Y, Gebretsadik A, French MD, et al. School water, sanitation, and hygiene, soil-transmitted helminths, and schistosomes: National mapping in Ethiopia. *PLoS Negl Trop Dis* 2016; **10**(3): 1-21.

[50]Tabi ESB, Eyong EM, Akum EA, Löve J, Cumber SN. Soil-transmitted helminth infection in the Tiko Health District, South West Region of Cameroon: A post-intervention survey on prevalence and intensity of infection among primary school children. *Pan Afr Med J* 2018; **30**(1). doi: 10.11604/pamj.2018.30.74.15676.

[51]Campbell SJ, Nery SV, D'Este CA, Gray DJ, McCarthy JS, Traub RJ, et al. Water, sanitation and hygiene related risk factors for soil-transmitted helminth and *Giardia duodenalis* infections in rural communities in Timor-Leste. *Int J Parasitol* 2016; **46**(12): 771-779.

Publisher's note

The Publisher of the *Journal* remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

———————————————————

Edited by Zhang Q, Lei Y, Pan Y