sciendo

DOI 10.2478/helm-2023-0005

HELMINTHOLOGIA, 60, 1: 28 – 35, 2023

Prevalence and distribution of urinary schistosomiasis among senior primary school pupils of Siphofaneni area in the low veld of Eswatini: A cross-sectional study

T. S. B. MASEKO[1], S. K. S. MASUKU[2], S. V. DLAMINI[3], C.-K. FAN[4,*]

[1]Research Department, University Research Co., LLC; [2]Department of Community Health; [3]Department of Environmental Health Sciences, Faculty of Health Sciences, University of Eswatini; [4,*]Department of Molecular Parasitology and Tropical Diseases, School of Medicine, College of Medicine, Taipei Medical University, 250, Wu-Xing Street, Taipei, Taiwan, E-mail: *tedfan@tmu.edu.tw*

Article info

Received April 5, 2022
Accepted February 21, 2023

Summary

A cross-sectional survey of *Schistosoma haematobium* prevalence was conducted among senior primary school pupils of Siphofaneni area, Eswatini. This area is devoid of potable water, with a newly constructed Lubovane dam and an LUSIP irrigation scheme. The objective of the study was to investigate the distribution of urinary schistosomiasis among Siphofaneni senior primary school pupils. Using simple random sampling, 200 partcipants were enroled from four of six schools in the area. Ten millimetres (10 ml) of urine samples were obtained from each participant and examined for *S. haematobium* eggs. The intensity of the infection was estimated by calculating the total number of *S. haematobium* eggs present in 10 ml urine. Out of 200 participants, 45% (n = 91) were males, and 55% (n = 109) were females. The mean age for participants was 13 years, and almost half (47%, n = 94) were in Grade 5. Overall, the prevalence of *S. haematobium* infection was 16% (32/200). More than half (59%, 19/32) of the Schistosomiasis cases were from females. Positive and significant associations were observed between the number of eggs (χ^2=170.9) and the presence of red blood cells (χ^2=49.2) at p = 0.001. In conclusion, the prevalence of Schistosomiasis is high among pupils enrolled in Siphofaneni area primary schools that needs comprehensive treatment and education to prevent from *S. haematobium* infection.

Keywords: Prevalence; Schistosomiasis haematobium; Senior primary school children; Eswatini

Introduction

Human schistosomiasis is a chronic disease caused by the blood flukes belonging to the genus *Schistosoma*. *Schistosoma haematobium (S. haematobium), S. mansoni, S. japonicum, S. mekongi and S. intercalatum* are the main species causing human infections (Geleta *et al*., 2015), which is the second major Neglected Tropical Diseases (NTDs) next to malaria. It affects over 250 million people globally whilst approximately 179 million people (Sacolo *et al*., 2018), especially children. People living within irrigation schemes or close proximity to dam reservoirs, primarily in sub-Saharan African settings are at high risk (Chitsulo *et al*., 2000; Steinmann *et al*., 2006; Weerakoon *et al*., 2015). Estimated more than 200,000 deaths occurs globally per annum due to schistosomiasis, and its burden is high in Africa with at least 90 % of those requiring treatment living in this region (Clements *et al*., 2009; Lai *et al*., 2015). Several factors including intensities of infection, concomitant infections, and immunologic predisposition partly explain this variation (Hafez *et al*., 1991; Fulford *et al*., 1998; King, 2010).

Water contact practices predispose people to schistosomiasis. All human *Schistosoma* infections follow direct contact with fresh water that harbours cercariae. When the person comes into contact with infested water, the cercariae penetrates the skin into the blood stream (Asundi *et al*., 2019).

* – corresponding author

The Kingdom of Eswatini (KES) is facing a high burden of communicable diseases particularly Human Immunodeficiency Virus (HIV), Tuberculosis and NTDs such as schistosomiasis. Children are the most affected group (Sanchez-Padilla *et al*., 2012; Horter *et al*., 2019). In 1984, a school survey conducted in the northern Lowveld reported a high prevalence (58 %) of urinary schistosomiasis with children 10 ~ 14 years old demonstrating a prevalence of 65.1 % (Chaine, 1984). *Schistosoma mansoni* was essentially limited to the Lowveld with a general prevalence of 18 % (Horter *et al*., 2019). In 2010, a similar survey conducted among the residents in the same study area revealed *S. haematobium* prevalence of 6.1 % (18/295) (Chu *et al*., 2010). Amongst suspected patients who visited the national bilharzia laboratory between 2007 and 2009, positive cases of *S. haematobium* were above 80 % (Rollinson *et al*., 2013). Positive cases among the suspected cases between 1999 and 2010 ranged from 60 % to 88 % (Rollinson *et al*., 2013). Another study conducted in the Northwestern Eswatini showed that schistosomiasis was a problem in Eswatini. Its findings revealed that the prevalence of *S. haematobium* infection was 5.3 % (21/395) with a AMI of 46.5. Boys had higher prevalence (7.1 %, 13/182) and AMI (50.4) than girls (3.8 %, 8/213; 40.0) did ($p < 0.05$) (Liao *et al*., 2011). Noteworthy is that the current prevalence of *S. mansoni* is unknown, unlike *S. haematobium* which prompts haematuria and force patients to seek medical attention, while *S. mansoni* does not show acute disease. In an effort to control the burden of schistosomiasis, the National Bilharzia Control Program (NBCP) was established in 1982 and was known as the Bilharzia Control Unit with the mandate to control bilharzia (Rollinson *et al*., 2013). In 2005, the program then became known as National Bilharzia Worm Control Program (NBWCP), following the expansion of its mandate to control both schistosomiasis and soil-transmitted helminthic infections (Maseko *et al*., 2018). It has been providing health education and routine de-worming of school-aged children every year since 2005 for routine control of bilharzia and other worm infections in the Lowveld, Middleveld, and Highveld of Eswatini with its efforts concentrated on high prevalence areas (Maseko *et al*., 2018). However, the de-worming programme was suspended in 2010 by the Ministry of Health, and as such the burden of worm infection is likely to have increased among the children since then (Maseko *et al*., 2018).

Many probable factors predispose people to schistosomiasis infection in Eswatini. For instance, the country still has sanitary problems. Only 59 % of the rural population has pit latrines and about 18 % still uses surface water (Kowalkowski *et al*., 2007). The Siphofaneni area is among the areas without sanitary water supply and local residents rely on rivers and dams for daily water needs. People of Siphofaneni use these water sources for domestic, recreational and agricultural purposes. This area located in the Lowveld of Eswatini experiences high temperatures, and the river flow is slow inland forming stagnant pools allowing vector snails to breed (Kowalkowski *et al*., 2007).

Since 2010, Lubovane dam and Lower Usuthu Smallholder Irrigation Project (LUSIP) managed by Eswatini Water Development Enterprise (EWADE) became the source of water in Siphofaneni (African Water Facility & African Development Bank, 2009). Such developments have likely increased schistosomiasis exposure and infection among the residents. For instance, in some parts of Senegal, *schistosomiasis* was encroached during dam construction and in 3 – 4 years it had spread rapidly and intensely. The mean prevalence of *S. mansoni* rose from 4.4 % in the lower Delta-Senegal River to 71.8 % with a mean number of 2088 eggs/g of faeces (Talla *et al*., 1990; Picquet *et al*., 1996). *S. haematobium* rose from a mean prevalence of 0.37 % in the lower valley to 41.5 %, with a mean egg count of 313/10 ml of urine (Verlé *et al*., 1994). Moreover, children are at a greater risk for schistosomiasis infection, particularly 5 to 14 years old, due to their water contact behaviours (Colley *et al*., 2014; Ezeamama *et al*., 2018). In Kenya, a study on *S. haematobium* in two villages found that being 10 – 12 years had significant odd of infection (OR= 4.17, $p < 0.05$) (Njaanake *et al*., 2016). It is also worth noting that after the establishment of the Lubovane dam and LUSIP irrigation scheme in Siphofaneni no study has been conducted to determine the prevalence of schistosomiasis. Therefore, this study aimed to bridge that gap to estimate the prevalence of schistosomiasis among senior primary school children (PSC) in Siphofaneni area, particularly of focusing on age group of 10 – 14 years, which is the age group of children mainly found in grades 5 – 7.

Materials and Methods

Study area

The KES is a landlocked country in southern Africa, bordered to the north, south, and west by South Africa, and to the east by Mozambique. Annual rainfall is highest on the Highveld, which the altitude is around 1200 meters, in the West, between 1000 and 2000 mm depending on the year. The further east, the less rain, with the Lowveld, which the altitude is around 250 meters, was recorded from 500 to 900 mm per annum. Variations in temperature are also related to the altitude of the different regions. The Highveld temperature is temperate and, seldom, uncomfortably hot while the Lowveld may record temperatures around 40°C in

Summer. In 2005, the National Bilharzia Worm Control Program (NBWCP) had expanded its mandate to a dual approach of morbidity control with provision of mass preventive chemotherapy (de-worming) using the antihelminthic tablets Praziquantel 600mg and Albendazole 400 mg for schistosomiasis (Bilharzia) and soil-transmitted helminthiasis (STH) control, respectively through repeated routine or regular control-dose treatment with inexpensive, single-dose and highly effective drugs, so safe can be given to all age groups at risk i.e., school-aged children aged 6 to 19 years-depending to the ecological zone location of the school. To attain at least 75 % to 100 % de-worming campaign coverage per round by 2015. The annual work achievement in the end of April 2013 to April 2014, NBWCP has accomplished 1500 and 6400

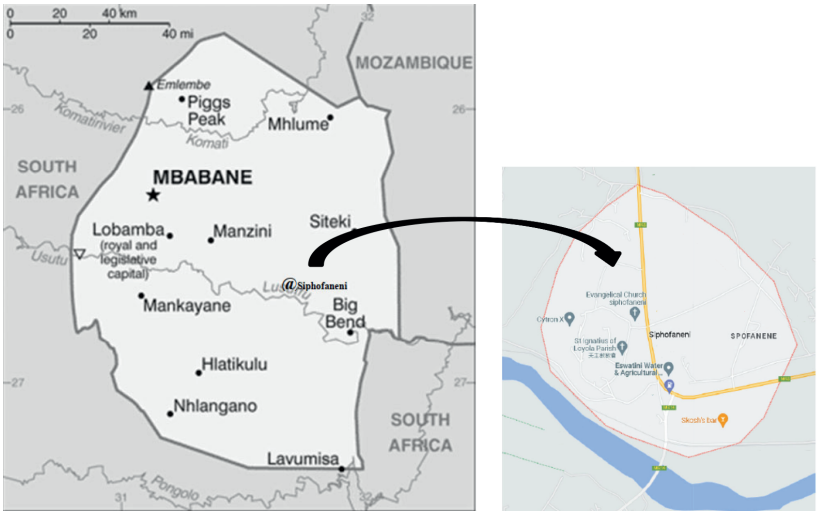

Fig. 1. Map of Eswatini, commercial at (@) indicating the study location-Siphofaneni. The enlarged map indicating the Siphofaneni area.

of cases treated for Bilharzia in the laboratory and in all health facilities, respectively. Meanwhile, the total numbers for routine drug distribution to PSC was 150000 around (Ministry of Health, Eswatini, 2021). Nevertheless, the status of the *S. haematobium* infection among residents in some remote districts located in Lowveld KES, which are not covered by NBWCP. This study was conducted from April 16 to May 15, 2015 in 4 of 6 primary schools of the Siphofaneni area, which is comprised of 0.779 km² with a total population of nearly 1200 and most residents are farmers, located in the Lowveld of Eswatini. Siphofaneni is a remote town in the Lubombo Region, with its location on the banks of the largest river – the Usutu in KES. It has a tropical climate, very hot during summer (annual average 25.2°C) and cold in winter (annual average 13.9°C). Siphofaneni lies within latitude 26° 41' 0" S and longitude 31° 40' 57" E (Fig. 1) (Chu *et al*., 2010). This area has many predisposing factors to schistosomiasis such as poor sanitation, lack of potable water, newly contracted Lubovane Dam and new LUSIP irrigation scheme, therefore, needs a parasitological survey of human infection.

Study population, questionnaire, sample size determination and detection method

A cross-sectional descriptive study design using quantitative approach was used for this study, however, girls who are at menstrual period will be excluded in this study. The sample size was determined using the general formula, $n = Z^2p\ (1- p)/d^2$ where, n

Table 1. Socio-demographic characteristics of participants.

Variable	Sample size (n)	%
Name of school		
Othandweni Primary	48	24.0
Madlenya Primary	42	21.0
Siphofaneni Primary	71	35.5
Mkhweli Primary	39	19.5
Age Group of participants		
10-14	170	85.0
≥15	30	15.0
Gender		
Male	91	45.5
Female	109	54.5
Present Grade		
Grade 5	94	47.0
Grade 6	68	34.0
Grade 7	38	19.0

is the sample size, *Z* (1.96) is the standard deviation at a 95 % confidence interval (CI), *p* is the estimated prevalence (15 %), and *d* is the allowed relative error (0.05) (Rutterford *et al*., 2015). The minimum sample size after calculation was 196 children. Totally, 49~50 PSC were allowed for each primary school from totally 4 participant primary schools to participate in this study hence the participant number of each grade from each school was 16~17 PSC. Therefore, in selecting participants for the study, they were first stratified according to their educational level (grades 5, 6, and 7), then randomly sampled using class rosters as the sampling frame. A total of 200 pupils within grades 5 – 7 were randomly sampled and enrolled into the study. Simple random sampling technique was chosen for this study because it allows representative of the population under study in sample, that is, all elements have an equal chance of being included in the sample and permits the researcher to estimate the sampling error, reduce bias during sampling and makes it possible to make inferential statistics correctly (Brink *et al*., 2006). The following data was collected using a questionnaire including age, gender, grade, and history of bilharzia treatment in the last six months as interviewed using local langue of Siswati by local public health nurse. A single terminal urine sample was collected from each participant between 10.00 and 14.00 hours, reportedly the maximum eggs excretion occurs (Chen & Mott, 1989). Ten milliliters of each of the well-mixed urine samples was poured into a quantitative centrifuge tube specific for urinary cells/parasites counting (cat. no. SY9504, Shin-Yung Medical Instruments Co., Ltd., Taipei City, Taiwan) centrifuged at 2000 rpm for 3min. The supernatant was discarded but about 0.6 ml residual urines were still retained in the bottom of tube and then 50 µl of the urinary solution was dropped into a slot in the counting chamber (cat. no. SY 9502); the identification criteria for *S. haematobium* eggs in the chamber previously described was applied, indicating a terminal spine was seen from the egg (Chu et al., 2010) thereafter the number of *S. haematobium* eggs present in the slot under the microscope at 100 x magnification was calculated, finally the number will be multiplied by 12 to represent a total number of eggs present in 10ml urine specimen. The mean number of eggs per 10 ml urine present in all of positive samples was defined as arithmetic mean intensity (AMI), and any samples that contained less than 50 eggs /10 ml was regarded as light infection; however, the figure was equal to or more than 50 eggs /10 ml were regarded as heavy infection as suggested by World Health Organization (Opara *et al*., 2007; Chu *et al*., 2010).

Statistical analysis

Collected data were entered and analysed using SPSS 20.0 software (IBM Corp., Armonk, NY, USA). To estimate the intensity of schistosomiasis infection, arithmetic mean intensity was estimated. To determine variables associated with the prevalence of schistosomiasis, *Chi-square* was done and $p < 0.05$ was regarded as significant difference.

Ethical Approval and/or Informed Consent

Ethical clearance was obtained from the Ethics and Scientific Committee of the Ministry of Health in Eswatini (Ref. No. MH/599C/ FWA 000 15267/ IRB 000 9688). Permission and approval were also obtained from the principal of each selected school and par-

Table 2. Prevalence and distribution of Schistosomiasis.

Variable	Sample size (n)	%
Reported blood in urine		
Yes	14	7.0
No	186	93.0
Treated for bilharzia in the past 6 months		
Yes	7	3.5
No	193	96.5
Prevalence of schistosomiasis		
Positive	32	16.0
Negative	168	84.0
Mean number of eggs in 10ml		
0 eggs	170	85.0
200 eggs	24	12.0
400 eggs	6	3.0
Presence of RBC in Urine		
Positive	82	41.0
Negative	118	59.0

ents/guardians of the children. Meetings were also held to explain to teachers and pupils the objectives and protocol of the study. Informed consent form was given and obtained from each participant to emphasize inclusion in the study are voluntary and withdrawal are allowed anytime. Those who declined participation were excluded from the study. Signed or thumb-printed consent was obtained from parents/guardians on behalf of their children before sample collection commenced.

Results

Out of 200 participants enrolled in the study, 54.5 % (109/200) were females and 45.5 % (91/200) were males. The mean age of participants was 13.0 ± 1.8 years old with the youngest and the oldest aged 12 and 22 years, respectively. Among the four schools that were sampled, a majority (35.5 %; 71/200) were pupils from Siphofaneni Primary School since it had the largest number of pupils in the respective grades. Least variation was observed in the number of pupils from the other schools Othandweni (24.0 %; 48/200), Madlenya (21.0 %; 42/200) and Mkhweli (20.0 %, 39/200). Data is shown in Table 1.

The overall prevalence of schistosomiasis was 16.0 % (32/200). Findings from this study showed a higher prevalence of schistosomiasis among girls compared to boys. Out of a total of 109 school girls, nineteen (17.4 %) were found to have schistosomiasis which is insignificantly higher than in school boys (14.3 %, 13/91) (p = 0.54). Among the participants, 3.5 % (7/200) of the participants reported that they have been treated for bilharzia in the last 6 months (Table 2), 7.0 % (14/200) reported that they were passing blood in urine (haematuria) at time of sample collection and all were laboratory confirmed positive for *S. haematobuim* eggs in urine samples, suggesting a high repeat of the *Schistosoma* infection for those children even after treatment.

The presence of red blood cells (χ^2=49.167) and a number of eggs in 10 ml (χ^2=170.942) urine were significantly associated with the prevalence of schistosomiasis at p = 0.001. This speculation that the prevalence of schistosomiasis may be underestimated based on the significant association between presence of RBCs in urine and schistosomiasis prevalence at p = 0.001 (Table 3).

Discussion

Present study showed that the overall prevalence of schistosomiasis was 16.0 % (32/200) and girls (17.4 %, 19/109) had an insignificantly higher prevalence than boys (14.3 %, 13/91). Those praziquantel-treated children still showed *Schistosoma* infection

Table 3. Factors associated with the prevalence of Schistosomiasis.

Variable	Schistosomiasis			
	Negative	Positive	χ^2	*p*-value
Gender			0.365	0.391
Males	78	13		
Females	90	19		
Reported blood in urine			ND	0.001*
No	168	18		
Yes	0	14		
Present grade			0.253	0.823
Grade 5	80	14		
Grade 6	57	11		
Grade 7	31	7		
History of bilharzia in the last 6 months			1.382	0.240
Yes	161	32		
No	7	0		
Number of eggs in 10 ml urine			170.942	0.001*
0	167	3		
200	1	23		
400	0	6		
Presence of RBC in urine			49.167	0.001*
No	117	1		
Yes	51	31		

and presence of urinary RBCs showed statistical association with schistosomiasis prevalence. It's suggested the possible underestimation of the schistosomiasis prevalence if misunderstood that after recent treatment didn't get any risk in *Schistosoma* infection again and that ignored the possibility that urinary RBCs presence was actually relevant to *Schistosoma* infection.

Findings from this study showed a higher prevalence of schistosomiasis among girls compared to boys. Our study revealed similar results as previous study conducted in 2010 in the same area which reported higher prevalence of schistosomiasis among females (10.5 %, 16/153) than males (1.4 %, 2/142) (ORs = 8.2, 95 % CI = 1.8 – 36.2, $p < 0.01$) (Chu *et al*., 2010), even though in this study didn't show significant. The higher prevalence in girls could be associated with improper health care provision, lack of medical awareness to disease mode of contraction, lack of free tap-water availability, poverty and most of all, in Eswatini girls are doing most of the domestic works, such as fetching water from water reservoir, washing clothes and playing in the water while doing domestic works. This high prevalence could also be related to most primary school children crossing the river for day-to-day schooling, visit peri-urban areas and swimming (Maseko *et al*., 2018).

This study finding showed high prevalence but may also underestimate the schistosomiasis prevalence within the school pupils. More participants had RBCs in urine compared to those who had *Schistosoma* eggs in their urine. When noting the significant association between having RBCs in urine and having schistosomiasis ($p = 0.001$) (see table 3), it is likely that those participants with RBCs in urine could be infected with schistosomiasis even that the eggs was not found in the sampled urine. Out of the 32 participants who had *S. haematobium* eggs isolated in urine, only seven had reported passing blood in urine out of the 82 participants with haematuria. More than half of the infected participants (18/32) did not report blood in urine. This suggests the importance of routine screening of schistosomiasis other than waiting for the children to present with symptoms. Similar findings were observed in South Kordofan State Sudan where 12 % of participants reported to be passing blood in urine yet *S. haematobium* eggs could be detected in only 6 % of the participants (Mustafa & Ahmed, 2012). Alternatively, it may be possible participants in the chronic stages were still present with haematuria, egg elimination in the urine is significantly lower and even it may not be present at this stage. A study for monitoring praziquantel efficacy against *S. haematobium* by Stete et al., (2012) showed that the delayed decrease of microhaematuria confirms that lesions in the urinary tract persist longer than egg excretion post-treatment. In addition, Nepal et al. (2019) indicated that bladder wall calcifications are a classic sign of chronic *Schistosoma* cystitis and should raise suspicion for the disease even in the absence of parasite eggs on microscopic urinalysis or positive serologic testing, which have low sensitivity for chronic infection.

This study shows that the prevalence of schistosomiasis increased much higher compared to the study done in 2010 in Siphofaneni (Chu *et al*., 2010). This increase can be attributed to the presence of the Lubovane Dam and LUSIP considering that in Senegal following construction of dams, schistosomiasis prevalence increased (Talla *et al*., 1990; Picquet *et al*., 1996).

Findings from this study also showed that having been diagnosed and or treated for bilharzia in past six months was not significantly associated with the prevalence of schistosomiasis, contrary to findings obtained in Yemen that showed a significant association with family history of schistosomiasis (Sady *et al*., 2013). Such a difference may result from the fact that those previously diagnosed and treated with praziquantel in the last 6 months might have benefited from the prophylactic effect of the drug hence had no *Schistosoma* eggs in urine. Other causes of the difference could be in sample sizes, our sample size was half that of Yemen and the difference in study settings. In Eswatini the study was conducted among school going pupils yet in Yemen it was a community-based study. However, findings from the study support that schistosomiasis is one of the serious prevalent conditions in Eswatini.

Limitations of the study were the few samples analysed and lacks of ultrasound device to screen the bladder wall to find the granuloma-like materials to assess the schistosomiasis stage. This will help distinguish haematuria without detection of eggs in early or chronic infection.

Based on the findings of the study, it is necessary that the National Bilharzia Worm Programme scale up health education sessions on schistosomiasis among school pupils and the community at large. Collaborative efforts towards access to safe water by the community and finally, active screening of bilharzia is essential and treatment of all cases to reduce the prevalence of Schistosomiasis. The reinstatement of schistosomiasis prophylactic treatment should also be an advocate. Periodic evaluation of prevalence and knowledge, attitudes, and practices of the children is necessary.

Conflicts of interest

The authors declare no conflicts of interest in this study.

References

African Water Facility & African Development Bank (2013): *Lower Usuthu Smallholder Irrigation Project Phase II Studies, Eswatini. Appraisal Report. 2009*. Retrieved December 1, 2022, from https://projectsportal.afdb.org/dataportal/VProject/show/P-SZ-AAC-004

Asundi, A., Beliavsky, A., Liu, X.J., Akaberi, A., Schwarzer, G., Bisoffi, Z., Ana Requena-Méndez, A., Shrier, I., Greenaway, C. (2019): Prevalence of strongyloidiasis and schistosomiasis among migrants: a systematic review and meta-analysis. *Lancet Glob Health,* 7: e236 – e248. DOI: 10.1016/S2214-109X(18)30490-X

Brink, H., van de Walt, C., van Rensburg, G. (2006): *Fundamentals of research methodology for health care professionals*. 2nd Edition, Cape Town, SA, Juta and Company Ltd, 226 pp.

Chaine, J.P. (1984): *Schistosomiasis prevalence and control in the Kingdom of Swaziland*. American Public Health Association International Division Academy for Educational Development and Bilharzia Control Unit Ministry of Health, Swaziland (1984) PNA-AS–641

Chen, M.G., Mott, K.E. (1989): Progress in the assessment of morbidity due to schistosomass. *Trop Dis Bull*, 86: 1 – 56

Chitsulo, L., Engels, D., Montresor, A., Savioli, L. (2000): The global status of schistosomiasis and its control. *Acta Tropica,* 77: 41 – 51. DOI: 10.1016/s0001-706x(00)00122-4

Chu, T.B., Liao, C.W., D'lamini, P., Chang, P.W., Chiu, W.T., Du, W.Y., Fan, C.K. (2010): Prevalence of *Schistosoma haematobium* infection among inhabitants of Lowveld, Swaziland, an endemic area for the disease. *Trop Biomed,* 27: 337 – 342

Clements, A.C., Firth, S., Dembelé, R., Garba, A., Touré, S., Sacko, M., Landouré, A., Bosqué-Oliva, E., Barnett, A.G., Brooker, S., *et al.* (2009): Use of Bayesian geostatistical prediction to estimate local variations in *Schistosoma haematobium* infection in western Africa. *Bull World Health Organ,* 87: 921 – 929. DOI: 10.2471/BLT.08.058933

Colley, D.G., Bustinduy, A.L., Secor, W.E., King, C.H. (2014): Human schistosomiasis. *Lancet*, 383: 2253 – 2264. DOI: 10.1016/S0140-6736(13)61949-2

Ezeamama, A. E., Bustinduy, A. L., Nkwata, A. K., Martinez, L., Pabalan, N., Boivin, M. J., King, C. H. (2018): Cognitive deficits and educational loss in children with schistosome infection-A systematic review and meta-analysis. *PLoS Negl Trop Dis*, 12: e0005524. DOI: 10.1371/journal.pntd.0005524

Fulford, A.J., Webster, M., Ouma, J.H., Kimani, G., Dunne, D.W. (1998): Puberty and age-related changes in susceptibility to schistosome infection. *Parasitol. Today*, 14: 23 – 26. DOI: 10.1016/s0169-4758(97)01168-x

Geleta, S., Alemu, A., Getie, S., Mekonnen, Z., Erko, B. (2015): Prevalence of urinary schistosomiasis and associated risk factors among Abobo Primary School children in Gambella Regional State, southwestern Ethiopia: a cross sectional study. *Parasit Vectors,* 8: 215. DOI: 10.1186/s13071-015-0822-5

Hafez, M., Hassan, S.A., El-Tahan, H., el-Shennawy, F., Khashaba, M., al-Tonbary, Y., el-Morsi, Z., el-Sallab, S., el-Desoky, I., el-Shazly, A., *et al*. (1991): Immunogenetic susceptibility for post-schistosomal hepatic fibrosis. *Am J Trop Med Hyg,* 44: 424 – 433. DOI: 10.4269/ajtmh.1991.44.424

Horter, S., Wringe, A., Thabede, Z., Dlamini, V., Kerschberger, B., Pasipamire, M., Lukhele, N., Rusch, B., Seeley, J. (2019): "Is it making any difference?" A qualitative study examining the treatment-taking experiences of asymptomatic people living with HIV in the context of Treat-all in Eswatini. *J Int AIDS Soc*, 22: e25220. DOI: 10.1002/jia2.25220

King, C.H. (2010): Parasites and poverty: the case of schistosomiasis. *Acta Tropica,* 113: 95 – 104. DOI: 10.1016/j.actatropica.2009.11.012

Kowalkowski, T., Cukrowska, E.M., Mkhatshwa, B.H., Buszewski, B. (2007): Statistical characterisation of water quality in Great Usuthu River (Swaziland). *J Environ Sci Health A Tox Hazard Subst Environ Eng,* 42: 1065 – 1072. DOI: 10.1080/10934520701418557

Lai, Y.S., Biedermann, P., Ekpo, U.F., Garba, A., Mathieu, E., Midzi, N., Mwinzi, P., N'Goran, E.K., Raso, G., Assaré, R.K., *et al*. (2015): Spatial distribution of schistosomiasis and treatment needs in sub-Saharan Africa: a systematic review and geostatistical analysis. *Lancet Infect Dis,* 15: 927 – 940. DOI: 10.1016/S1473-3099(15)00066-3

Liao, C.W., Sukati, H., Nara, T., Tsubouchi, A., Chou, C.M., Jian, J.Y., Huang, Y.C., Chang, P.W.S., Chiu, W.T., Huang, Y.H., *et al*. (2011): Prevalence of *Schistosoma haematobium* infection among schoolchildren in remote areas devoid of sanitation in northwestern Swaziland, Southern Africa. *Jpn J Infect Dis,* 64: 322 – 326

Mascarenhas, A., Isabel Castro, I. (2011): A rare case of hematuria. *Einstein (Sao Paulo)*, 9(1): 81 – 83. DOI: 10.1590/S1679-45082011RC1946

Maseko, T.S.B., Mkhonta, N.R., Masuku, S.K.S., Dlamini, S.V., Fan, C.K. (2018): Schistosomiasis knowledge, attitude, practices and associated factors among primary school children in Siphofaneni area in the Lowveld of Swaziland. *J Microbiol Immunol Infect,* 51: 103 – 109. DOI: 10.1016/j.jmii.2015.12.003

Ministry of Health, Eswatini (2021): Retrieved December 1, 2022, from departments-sp-654042511?id=562

Mustafa, K., Ahmed, B. (2012): Prevalence of Schistosomiasis among School Children-South Kordofan State. *Neelain Med J*, 2: 12 – 23

Nepal, P., Ojili, V., Songmen, S., Batchala, P., Kumar, D., Nagar, A.M. (2019): Multisystem imaging review of human schistosomiasis: characteristic imaging findings. *Clin Imaging*, 54: 163 – 171. DOI: 10.1016/j.clinimag.2019.01.011

Njaanake, K.H., Vennervald, B.J., Simonsen, P.E., Madsen, H., Mukoko, D.A., Kimani, G., Jaoko, W.G., Estambale, B.B. (2016): *Schistosoma haematobium* and soil-transmitted Helminths in Tana Delta District of Kenya: infection and morbidity patterns in primary schoolchildren from two isolated villages. *BMC Infect Dis*, 16: 57. DOI: 10.1186/s12879-016-1387-4

Picquet, M., Ernould, J.C., Vercruysse, J., Niang, M., Rollinson, D. (1996): The epidemiology of human schistosomiasis in the Senegal river basin. *Trans Roy Soc Trop Med Hyg,* 90: 340 – 346. DOI: 10.1016/s0035-9203(96)90501-5

Rollinson, D., Knopp, S., Levitz, S., Stothard, J.R., Tchuem, T.L.A., Garba, A., Mohammed, K.A., Schur, N., Person, B., Colley, D.G., *et al*. (2013): Time to set the agenda for schistosomiasis elimination. *Acta Tropica*, 128: 423 – 440. DOI: 10.1016/j.actatropica.2012.04.013

Rutterford, C., Copas, A., Eldridge, S. (2015): Methods for sample size determination in cluster randomized trials. *Int J Epidemiol*, 44: 1051 – 1067. DOI: 10.1093/ije/dyv113

Sacolo, H., Chimbari, M., Kalinda, C. (2018): Knowledge, attitudes and practices on Schistosomiasis in sub-Saharan Africa: a systematic review. *BMC Infect Dis,* 18: 46. DOI: 10.1186/s12879-017-2923-6

Sady, H., Al-Mekhlafi, H.M., Mahdy, M.A., Lim, Y.A., Mahmud, R., Surin, J. (2013): Prevalence and associated factors of Schistosomiasis among children in Yemen: implications for an effective control programme. *PLoS Negl Trop Dis*, 7: e2377. DOI: 10.1371/journal.pntd.0002377

Sanchez-Padilla, E., Dlamini, T., Ascorra, A., Rüsch-Gerdes, S., Tefera, Z.D., Calain, P., de la Tour, R., Jochims, F., Richter, E., Bonnet, M. (2012): High prevalence of multidrug-resistant tuberculosis, Swaziland, 2009 – 2010. *Emerg Infect Dis,* 18: 29 – 37. DOI: 10.3201/eid1801.110850

Steinmann, P., Keiser, J., Bos, R., Tanner, M., Utzinger J. (2006): Schistosomiasis and water resources development: systematic review, meta-analysis, and estimates of people at risk. *Lancet Infect Dis,* 6: 411 – 425. DOI: 10.1016/S1473-3099(06)70521-7

Talla, I., Kongs, A., Verlé, P., Belot, J., Sarr, S., Coll, A.M. (1990): Outbreak of intestinal schistosomiasis in the Senegal River Basin. *Ann Soc Belg Med Trop*, 70: 173 – 180

Verlé, P., Stelma, F., Desreumaux, P., Dieng, A., Diaw, O., Kongs, A., Niang, M., Sow, S., Talla, I., Sturrock, R.F., *et al*. (1994): Preliminary study of urinary schistosomiasis in a village in the delta of the Senegal river basin, Senegal. *Trans Roy Soc Trop Med Hyg*, 88: 401 – 405. DOI: 10.1016/0035-9203(94)90400-6

Weerakoon, K.G., Gobert, G.N., Cai, P., McManus, D.P. (2015): Advances in the diagnosis of human schistosomiasis. *Clin Microbiol Rev,* 28: 939 – 967. DOI: 10.1128/CMR.00137-14