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Urinary schistosomosis in patients of rural medical health centers in Kwale county, Kenya

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Summary

Urinary schistosomosis is a serious public health problem prevalent in low-income rural regions of sub-Saharan Africa, including coastal part of Kenya. Praziquantel administration to school-aged children is the prevailing tool of schistosomosis control in these regions. The aim of our study was to find out if this control strategy can lead to interruption of parasite trasmission and disease elimination. During February and March 2018, the occurrence of urinary schistosomosis in volunteers of primary health care facilities in Kwale County, Kenya was examined and the occurrence of infected intermediate hosts *Bulinus globosus* in local water resources was monitored. Participants completed a questionnaire concerning source of water for household purposes, type of housing and health status and were asked to provide urine samples. Diagnosis of urinary schistosomosis was established by detection of *Schistosoma haematobium* eggs in urine specimens microscopically, using filtration method. Infected *B. globosus* snails were detected using cercaria shedding tests. From the hemolymph of snails, prepatent period of infection was identified by polymerase chain reaction (PCR). The presence of urinary schistosomosis was detected in 15.07 % (69 out of 451) of study participants. Cercaria shedding test was positive in 2 particular sites of river Pengo and Tsanganyiko. Genetic material (haemolymph) of 68 *B. globosus* snails tested by DraI PCR revealed 7 *Schistosoma* spp. positive samples. Six of seven DraI positive snails were infected by *S. haematobium,* as it was detected by Sh110/SmS1 PCR. The study revealed, that the disease was still present in the region studied and the transmission was not interrupted. The rate of infection was significantly influenced by the water supplies used for household purposes and the type of housing.
Keywords: *Schistosoma haematobium*; urinary schistosomosis; parasite transmission

Introduction

Urinary schistosomosis (known also as snail fever or bilharzia), caused by parasitic blood trematode *S. haematobium*, is prevalent in regions with lack of clean water and sanitation systems in the home, often in rural regions of sub-Saharan Africa (Bruun and Aagaard-Hansen, 2008). Humans become infected when they come in contact with contaminated water sources infested by *S. haematobium* cercariae that are released from intermediate hosts – freshwater snails of the genus *Bulinus.*

Urinary schistosomosis causes a serious public health problem in coastal parts of Kwale county, Kenya. Regular praziquantel administration to school-aged children over the past years might lower the disease prevalence and reduce morbidity. It seems that interruption of transmission might be essential for the successful elimination of the disease. The intermediate host – freshwater snail of

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the genus *Bulinus* – releases cercarial larvae in the water. If they come into contact with human skin, they penetrate it within minutes and migrate via the blood circulation to the portal vein. In this place they develop into the tiny immature flukes called schistosomulae. In the portal vein schistosomulae mature, copulate, and the constantly paired couples migrate to perivesicular venous plexus. Fertilised females lay eggs, which may move through the vessels and enter the cavity of the bladder to be excreted. Ciliated miracidia released from the eggs after hatching move actively and seek for their intermediate host, thus completing the life cycle. However, some of the eggs may be retained in tissues of the hosts inducing immune response and inflammation process, which may lead to various pathological consequences. Untreated infection can lead into painful urination, suprapubic discomfort, haematuria, inflammatory and granulomatous lesions in the male and female urinary systems. Anaemia, bladder cancer, kidney failure as well as co-infection with some viruses, bacteria, or parasites are another possible complications of disease in the later stages (El Ridi and Tallima, 2013). In spite of the fact, that people with mild worm burdens can have minimal or no symptoms, the health implications of the disease may be far-reaching (Gryseels *et al.*, 2006). Efforts to control morbidity of schistosomosis is increasing in countries of sub-Saharan Africa, including endemic region parts of Kenya. In these areas*, S. haematobium* infection control is focused on regular administration of single dose of praziquantel to school-aged children, referred to as mass drug administration (MDA) (N'goran *et al.,* 2003; Muhumuza *et al.,*2014).

The main objective of our study was to evaluate the impact of the control strategies on the transmission of schistosomiasis in the area studied. Therefore, during February and March 2018, the occurrence of urinary schistosomosis in patients of primary health care facilities was examined and at the same time the occurrence of infected intermediate hosts *Bulinus globosus* in selected local water resources was monitored.

Materials and Methods

Specimens of urine and questionnaire answers were obtained from individuals/patients of cooperating primary health care facilities in Kwale County, Kenya – Mwachiga Dispensary (Kinango Constituency, Kinango Location, Dumbule Sub Location), Mwaluphamba Dispensary (Matuga Constituency, Mwaluphamba Location, Mlafyeni Sub Location), Bilashaka Dispensary (Matuga Constituency, Tsimba Golini Location, Tsimba Golini Sub Location) a Mbuwani Dispensary (Msambweni Constituency, Diani Location, Msambweni Sub Location). Snails were collected from the selected places of water bodies localised on rivers Mbeto, Kombo, Bora, Ndugunane, Jarumani and Ramoyo in the surroundings of Mwachinga Dispensary; rivers Bechone Swabirina, Mbadzi, Tsanganyiko, Bangoni, Komanazilale, Mzizima in the surroundings of Mwaluphamba Dispensary as well as rivers Buburu, Kivumiro, Chimambani and Mbararani in the surroundings of Bilashaka Dispensary (Fig.1).

All of these areas are endemic only for urinary schistosomiasis caused by *S. haematobium*. Inhabitants of these remote villages work mostly as peasant farmers or casual workers. Most of them declare an acces to sanitation system in the form of pit latrines and access to clean water - *e.g.,* in Mwachinga Japan International Cooperation Agency constructed water kiosk for villagers. However, they still use water from lakes, rivers and ponds for watering animals, bathing or washing clothes, as was shown by questionnaire results. In the framework of deworming programme, in Mwaluphamba, Bilashaka and Mbuwani, co-administration of praziquantel (against urinary schistosomiasis) and albendazole (against soil-transmitted helminth infections) to community and school children was performed once a year in follwoing years: 2004, 2005,2007, 2009 and 2012. To date, praziquantel is applied in these areas to school-children once a year. In Mwachinga, praziquantel was administered to both school children and community yearly from 1998 – 2007. From 2010 to date, it is applied to school-children once a year.

Inclusion/exclusion criteria of the study participants

The aim of our study was to monitor *S. haematobium* infection in volunteers of different ages to be able to evaluate their contribution to the disease transmission. Therefore, all patients of primary health care facilities who were willing to complete a questionnaire and sign informed consent were enrolled into the study, except menstruating female volunteers. The urine samples were analyzed the same day in the laboratory section (corner/room) of these cooperating health care centers (dispensaries).

Informed consent, questionnaire, and urine sample collection

From February 19th – March 16th, 2018 randomly selected individuals/patients of primary health care facilities were contacted by local health officials who explained to them about voluntary participation and objectives of the study. Parents/care-takers were asked to give their ageement on behalf of participating minors. After acceptance to be enrolled in the study, participants (or parents/care-takers) were asked to sign informed consent and complete a short questionnaire concerning health status, source of water used, previous history of praziquantel administration and awareness of disease transmission. Samples of urine were assigned with the identification number and processed the same day in the laboratory section of health facilities. In urine specimens, macrohematuria was detected visually. For the presence of microhaematuria in the urine samples, diagnostic strips Hemophan (Erba Lachema Ltd., Brno, Czech Republic) working on the basis of chemical reaction of hemoglobin with chemicals on the reagent pad of the strip were used. Then, 10 ml of urine sample was passed through the Nucleopore membrane filter (25 mm, pore size 8 μm). The filter was then placed on a microscope glass slide and the eggs of *S. haematobium* were detected under the microscope at a magnification of x 400. The intensity of infection was expressed as light (L), medium (M) or heavy (H) according to the number of eggs per 10 ml

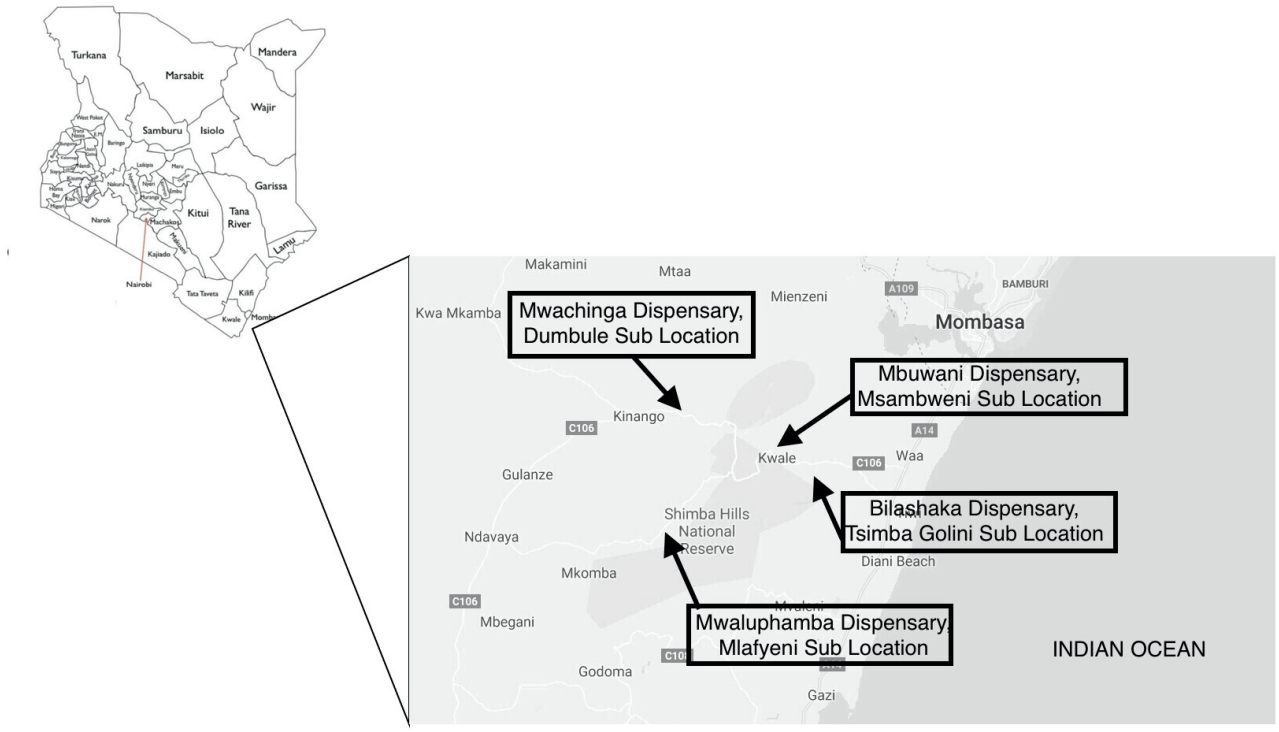

Fig.1. Map showing the location of areas included in survey, Kwale County, Kenya.

of urine (light: 1 – 4 eggs, medium: 5 – 49 eggs, heavy: ≥ 50 eggs). Participants found positive for *S. haematobium* infection throughout the study were treated with praziquantel in cooperation with primary health care facility workers.

Field procedures

Cercariae of infected freshwater snails were detected with the assistance of NUITM-KEMRI workers using cercaria shedding test. Snails were collected from the selected places of water bodies localised in the surroundings of cooperating health facilities, as described earlier. For this purpose scoop from steel sieves was used. Snails were then placed into a collecting pot containing water from the habitat, and supporting data such as date and time of collection, water and air temperature as well as site and weather conditions were recorded. After identification of snails based on shell morphological characteristics, cercaria shedding test was performed. The snails were placed in 24-well culture plates individually and exposed to indirect sunlight for 2 hours to induce cercaria shedding. The wells of the plates were then examined for the presence of cercariae under a binocular microscope (magnification 40x). Visually identified cercariae were then captured in 2 µl of fresh water and pipetted onto sample areas of Whatman Elute FTA micro cards.

Moreover, Whatman FTA Elute cards were used to trap the genetic material of the snails (hemolymph), keeping it stable and safe at room temperature and easily transportable. The presence of prepatent stadium of parasite in *B. globosus* snails was then tested by polymerase chain reaction (PCR).

Table 1. Basic characteristic of study group.

	n (%)
Female	323 (71.62%)
Male	128 (28.32%)
Age	
Less than 10 years	7 (1.55%)
10 – 15 years	106 (23.50%)
16 – 20 years	65 (14.41%)
21 – 26 years	57 (12.64%)
27 – 35 years	98 (21.73%)
36 and more years	118 (26.16%)
Study area	
Mwachinga Dispensary	117 (25.94%)
Mwaluphamba Disp.	124 (27.49%)
Bilashaka Dispensary	122 (27.05%)
Mbuwani Dispensary	88 (19.51%)

Table 2. Presence of *S. haematobium* eggs in urine by gender and study area, n=451.

Gender	Negative	Positive	*p-value*; χ^2
Female			**0.483168; 0.4917***
Mwachinga Dispensary	74 (22.91 %)	7 (2.17 %)	
Mwaluphamba Disp.	66 (20.43 %)	18 (5.57 %)	
Bilashaka Disp.	73 (22.60 %)	21 (6.50 %)	
Mbuwani Disp.	63 (19.50 %)	1 (0.31 %)	
Total (n=323)	**276 (85.45 %)**	**47 (14.55 %)**	
Male			
Mwachinga Dispensary	29 (22.66 %)	7 (5.47 %)	
Mwaluphamba Disp.	31 (24.22 %)	9(7.03 %)	
Bilashaka Disp.	22 (17.19 %)	6 (4.69 %)	
Mbuwani Disp.	24 (18.75 %)	0 (0.00 %)	
Total (n=128)	**106 (82.81 %)**	**22 (17.19 %)**	
Study area			
Mwachinga	103 (88.03 %)	14 (11.97 %)	
Mwaluphamba	97 (78.23 %)	27 (21.77 %)	
Bilashaka	95 (77.87 %)	27 (22.13 %)	
Mbuwani	87(98.86 %)	1(1.14 %)	
Total	**382 (84.70 %)**	**69 (15.30 %)**	
Mwachinga Dispensary			
Less than 10 years	0 (0.00 %)	1 (100 %)	
10 – 15 years	23 (79.31 %)	6 (20.69 %)	
16 – 20 years	13 (86.67 %)	2 (13.33 %)	
21 – 26 years	9 (81.82 %)	2 (18.18 %)	
27 – 35 years	27 (93.10 %)	2 (6.90 %)	
36 and more years	31 (96.88 %)	1(3.12 %)	
Total	**103 (88.03 %)**	**14 (11.97 %)**	
Mwaluphamba Dispensary			
Less than 10 years	5 (83.33 %)	1 (16.67 %)	
10 – 15 years	31 (75.61 %)	10 (24.39 %)	
16 – 20 years	23 (79.31 %)	6 (20.69 %)	
21 – 26 years	12 (80.00 %)	3 (20.00 %)	
27 – 35 years	11 (78.57 %)	3 (21.43 %)	
36 and more years	15 (78.95 %)	4 (21.05 %)	
Total	**97 (78.23 %)**	**27 (21.77 %)**	
Bilashaka Dispensary			
Less than 10 years	0 (0.00 %)	0 (0.00 %)	
10 – 15 years	16 (69.57 %)	7 (30.43 %)	
16 – 20 years	9 (75.00 %)	3 (25.00 %)	
21 – 26 years	14 (82.35 %)	3 (17.65 %)	
27 – 35 years	28 (82.35 %)	6 (17.65 %)	
36 and more years	28 (77.78 %)	8 (22.22 %)	
Total	**95 (77.87 %)**	**27 (22.13 %)**	
Mbuwani Dispensary			
Less than 10 years	0 (0.00 %)	0 (0.00 %)	
10 – 15 years	13 (100.00 %)	0 (0.00 %)	
16 – 20 years	9 (100.00 %)	0 (0.00 %)	
21 – 26 years	13 (92.86 %)	1(7.14 %)	
27 – 35 years	20 (100.00 %)	0 (0.00 %)	
36 and more years	32 (100.00 %)	0 (0.00 %)	
Total	**87 (98.86 %)**	**1 (1.14 %)**	

**p-value* and χ^2 is related to differences between males and females altogether

PCR detection of S. haematobium DNA from B. globosus

For DNA extraction a 3 mm disc containing the sample was punched out of the Whatman FTA Elute cards (GE Whatman, Maidstone, Kent, United Kingdom). The discs were then placed into a microcentrifuge tubes containing 500 µl of PCR water and vortexed 3 times for 5 seconds at high speed. After removal of excess wash water from the tubes, 35 µl of PCR water was added to the punch. Samples were incubated at 95 °C for 30 min and then centrifuged to separate the matrix from the eluate containing DNA. Using sterile pipette tips, the discs were removed from the tubes and discarded.

Primers for two PCR assays were designed on the basis of previously published sequence information (Amarir *et al.*, 2014). DraI PCR was performed using commercially available ready-to use mastermix My Taq™Mix, 2x (Bioline, London, UK), DraI primers (forward: GATCTCACCTATCAGACG, reverse: GTCAC-CAATAATATGAAAC), and target DNA.

To distinguish *S. haematobium* from other relative species - *e.g., S. bovis,* which is sympatric with *S. haematobium* in many endemic areas - the DNA of DraI positive snails were analysed by Sh110/SmSl PCR that was unique for *S. haematobium*. The primer combination used included Sh110 primer: 5'- TTC CTC CAA CTA CCA TCT TAT CTC-3'and Sm-Sl primer: 5'- AAC CGT CAC GGT TTT ACT CTT GTG-3'. PCR conditions for both assays were set at 95 °C for 5 min for initial denaturation, followed by 35 cycles of 95 °C for 1 min (denaturation), 35 cycles of 55 °C for 1 min (annealing) and 35 cycles of 75 °C for 1 min (extension). Using UV trans-illumination, the amplified products then were visualized on 1.5 % agarose gel stained with fluorescent nucleic acid dye GelRed™.

Data analysis

Basic descriptive analysis was performed, differences in proportions were compared by the Chi square ($\chi 2$) test using R software, version 3.4.0. Statistical significance was set at a p -value of 0.05.

Ethical Approval

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

Results

From February 19 – March 16, 2018 a total of 451 participants (323 women and 128 men) were involved into the study. The research team examined 117 samples in Mwachiga Dispensary, 124 in Mwaluphamba Dispensary, 122 in Bilashaka Dispensary and 88 in Mbuwani Dispensary. The basic characteristic of the study group is presented in Table 1.

The presence of *S. haematobium* eggs was detected in urine specimens of 15.30 % (69 out of 451) of study participants altogether; 11.97 % (14 out of 117) in urine samples of participants in Mwachinga Dispensary, 21.77 % (27 out of 124) in Mwaluphamba Dispensary and 22.13 % (27 out of 122) in Bilashaka Dispensary. In Mbuwani Dispensary we detected the presence of *S. haematobium* eggs only in one urine sample (1.14 %).

Of 451 participants (323 women and 128 men) who were examined for the presence of eggs in urine samples, 47 women and 22 men were detected as schistosomosis positive. Men (17.19 %) had a slightly higher rate of infection than women (14.55 %), but this difference was not statistically significant ($\chi^2 = 0.48$; p = 0.49) (Table 2).

Out of 451 of study participants 53 (11.75 %) reported access to borehole water, the rest of them used ponds, lakes, rivers, backwaters, or water from tanks as a source of household water or water for animals. The significantly higher infection rate was found among participants who used environmental water sources such as rivers, ponds, or backwaters (14.6%) in comparison to those, who reported access to the borehole water (0.6%) for household purposes or as a source of water for animals ($\chi^2 = 4.99$; OR = 5.04; 95 % CI 1.19 – 21.24; p = 0.025). Similarly, participants living in traditional houses made of mud showed a significantly higher number of *Schistosoma* infection cases than those living in concrete houses ($\chi^2 = 5.18$; OR = 2.18; 95 % CI 95 % 1.13 – 4.22; p = 0.02).

The comparison between haematuria and infection status revealed, that 47 individuals (out of 69) with detected *S. haematobium* eggs in the urine samples were screened positive for haematuria, whereas the rest (n = 22) had no sign of haematuria. Inversely, 97 of the participants were found to be *S. haematobium* infection negative, although they demonstrated haematuria and 284 were both infection and haematuria negative.

The presence/absence of *S. haematobium* eggs in the urine with/without haematuria is shown in Table 3.

Table 3. The presence/absence of *S. haematobium* eggs in the urine with/without haematuria.

	Eggs pos.	Eggs neg.	Total
Haematuria pos.	47 (10.42 %)	97(21.5 %)	144
Haematuria neg.	22 (4. 87 %)	285(63.19)	307
Total	69	382	451 (100 %)

Sensitivity rate = 68 %, specificity rate = 74 %, positive predictive value = 32 %, negative predictive value = 92 %, validity = 74 %.

Table 4. Presence of *B. globosus* and cercaria shedding test results in selected local water resources.

Date of collection	Locality/area	Water source	*B. globosus* (n)	Cercaria shedding test
23.02.18	Mwachinga	Mbeto river	0	_
23.02.18	Mwachinga	Kombo river	0	_
26.02.18	Mwachinga	Bora river	31	neg.
27.02.18	Mwachinga	Ndugunane river	10	neg.
28.02.18	Mwachinga	Jarumani river	13	neg.
01.03.18	Mwachinga	Ramoyo river	21	neg.
02.03.18	Mwaluphamba	Bechone Swabirina river	27	neg.
02.03.18	Mwaluphamba	Pengo river	23	pos.
05.03.18	Mwaluphamba	Mbadzi river	0	_
05.03.18	Mwaluphamba	Bangoni river	11	pos.
06.03.18	Mwaluphamba	Tsanganyiko river	30	pos.
07.03.18	Mwaluphamba	Komanazilale	3	neg.
08.03.18	Mwaluphamba	Mzizima river	0	_
12.03.18	Bilashaka	Buburu river, 1. site	28	neg.
12.03.18	Bilashaka	Buburu river, 2. site	15	neg.
13.03.18	Bilashaka	Kivumiro river, site 1	5	neg.
13.03.18	Bilashaka	Kivumiro river, site 2	5	neg.
14.03.18	Bilashaka	Chimambani river	32	neg.
15.03.18	Bilashaka	Mbararani river, 1. site	11	neg.
15.03.18	Bilashaka	Mbararani river, 2. site	24	neg.

However, after stratification of the intensity of *S. haematobium* infection by light (n = 50), medium (n = 10) and heavy (n = 9), it was seen that all cases of heavy infections (i.e., 50 or more eggs/10 ml of urine) were connected with documented haematuria in the urine samples.

Nine of 69 infection-positive and 36 of infection-negative participants reported treatment with praziquantel in the past 6 months. There was no significant difference between infection positivity of treated and un-treated group of patients (χ^2 = 0.85; OR = 1.44; 95 % CI 0.66 – 3.15; p = 0.36). Nine infection-positive participants belonged to the age group 10 – 15 years; 29 infection positive participants were in age group 16 – 20 years, 11 in age group 20 – 25 years, 10 in age group 26 – 35 years, 9 were older than 36 years and 1 positive participant was 6 years old.

Intermediate host of infection in these regions – *B. globosus* – was found in 10 out of 16 screened water resources. Cercaria shedding test was positive in 2 particular sites of river Pengo and Tsanganyiko (Table 4).

Genetic material of 68 *B. globosus* snails tested by DraI PCR revealed 7 positive samples. Confirmation by Sh110/SmSl PCR showed that 6 of 7 DraI positive snails were infected by *S. haematobium*. The positive snails came from the rivers Mbararani, Buburu, Kiwumiro and Bangoni.

Discussion

Efforts to control morbidity of schistosomosis as well as other helminthosis is increasing in many countries of sub-Saharan Africa, including Kenya – School Based Deworming Programme is one of the main tool of control focused on regular administration of a single dose of anthihelminth drugs to school-aged children. At the end of the twentieth century the prevalence of *S. haematobium* infection was >70% among school-aged children in Kwale County, Kenya (King *et al.*, 1988, Sato *et al., 1988*). Recent publications refer that more than 30 % of schoolchildren could be infected with *S. haematobium* in this part of Kenya (Bustinduy, 2013, Chadeka, 2017, Njenga, 2014). In the framework of deworming programme, in Mwaluphamba, Bilashaka and Mbuwani, co-administration of praziquantel (against urinary schistosomiasis) and albendazole (against soil-transmitted helminth infections) to community and school children was performed once a year in follwoing years: 2004, 2005,2007, 2009 and 2012. To date, praziquantel is applied in these areas to school-children once a year. In Mwachinga, praziquantel was administered to both school children and community yearly from 1998 – 2007. From 2010 to date, it is applied to school-children once a year.

However, this regular treatment approach cannot interrupt schis-

tosomosis transmission, as is indicated by a number of authors (Njenga *et al.,* 2014; Adenowo *et al.,* 2015; Sokolow *et al.,*2016). This is congruent also with our study conducted in Kwale County, Kenya in February-March, 2018. Our survey revealed some areas with a higher proportion of study participants infected with *S. haematobium* (i.e., the catchment areas of Mwachinga, Mwaluphamba and Bilashaka Dispensaries with 11.96 %, 20.96 % and 22.13 % of infected individuals, respectively), while the other locality surveyed (catchment area of Mbuwani Dispensary) showed only a very slight proportion of infected subjects (1.13 %). The focal character of schistosomosis transmission was documented by a number of relevant publications (Brooker, 2002; Clennon *et al.,* 2006; Meurs *et al.,* 2013; Chadeka *et al.,* 2017), suggesting a public health problem in geographically restricted localities. The difference between men and women in the prevalence of schistosomosis was not statistically significant (17.18 % and 14.55 %, respectively; p = 0.48). However, there was a higher sex ratio in favor of women among the participants in our study, which was caused by the proportion of patients in primary health care facilities, focusing mainly on reproductive, maternal and child health care services.

The results of studies dealing with gender effect on the prevalence of urinary schistosomosis are inconsistent, moreover, the majority of them were evaluating data collected from school children or preschool children, in contrast to our study, in which also older age categories were included (Nkegbe *et al.,* 2010; Ekpo *et al.,* 2011; Kayuni *et al.,*2017). Males may be involved in water-contact activities such as cattle watering, preparing materials for construction of buildings or farming, while females in laundry, household cleaning and other domestic works – with no diffefence in exposure to the risk factor. The significantly higher infection rate was found among participants who used environmental water sources as rivers, ponds, or backwaters in comparison to those, who reported access to the borehole water for household purposes or as a source of water for animals (χ^2 = 4.99; OR = 5.04; 95 % CI 1.19 – 21.24; p = 0.025). This is consistent with Singh *et al.* (2016), who in Sokoto, Nigeria, reported higher occurrence of urinary schistosomosis among those using dam water as a water supply for drinking (75.24 %) in comparison to those who used water from boreholes (17.64 %). Also Grimes *et al.* (2014) who carried out a systematic meta-analysis of studies reporting *S. haematobium* infection rate suggested, that safe water supplies were associated with significantly lower odds of schistosomosis. In contrast to these findings, Kholy *et al.* (1989) state that borehole well introduction had minimal impact on transmission of schistosomosis in 3 endemic villages in Kenya. Also Mutuku *et al.*(2011) indicate, that residents in some infection areas might prefer pond and river water for laundry and bathing over the hard water from borehole wells.

The significantly higher rate of detected schistosomosis in participants living in traditional mud houses found in our study (χ^2 = 5.18; OR = 2.18; 95 % CI 95 % 1.13 – 4.22; p = 0.02)

may be connected with a lower socioeconomic status of their inhabitants rather than the construction material itself. Sady *et al.* (2013) indicated, that low household monthly income was one of the key factors significantly associated with schistosomosis among children in rural areas in Yemen. An association between schistosomosis and socioeconomic conditions was pointed out also by study of Ximenes *et al.* (2006). Socioeconomic development connected with implementation of adequate water supply, sewage system, sanitation facilities and health education could have permanent positive effect on the control of schistosomosis (Ximenes, 2006; Sady, 2013).

In highly endemic areas, detection of hematuria could serve as a proxy indicator for *S. haematobium* infection identification (Anosike *et al*. 2001; French *et al.* 2007; Houmsou *et al.* 2011). The validity of haematuria as a diagnostic criterion for urinary schistosomosis screening was discussed in a number of publications (King*et al*., 2013; Krauth *et al.* 2015; Ochodo*et al*., 2015; Knopp *et al*., 2018). In our study, dipstick test sensitivity and specificity for detection of egg-positive urine were estimated at 68 % and 74 %, respectively (Table 3). However, after stratification of the intensity of *S. haematobium* infection by light, medium and heavy, we observed a substantial increase in the sensitivity rate of the dipstick test in heavy infections. This is in agreement with the results of other studies (King *et al*.,2013; Krauth *et al*., 2015), which found that the sensitivity of the hematuria test is reduced in groups with light intensity infections.

Nine of 69 infection-positive participants reported medication with praziquantel in the past 6 months. All of these 9 participants belonged to the age group 10 – 15 years, so they were involved in the programme of MDA to school-aged children. However, after a treatment with praziquantel, they might get re-infected during their contact with water infested with *S. haematobium* positive intermediate hosts. Infected study participants excluded from deworming programme may contribute to water infestation via excreted parasite ova.

In order to estimate disease transmission, suspected water bodies localised in the surroundings of cooperating health facilities were monitored. After scooping, snails of the genus *Bulinus* were morphologically identified and cercaria shedding test was performed. The intermediate host of infection – *B. globosus* – was found in 10 out of 16 screened water resources. The cercaria shedding test was positive in 2 particular sites of river Pengo and Tsanganyiko. Moreover, from the genetic material (haemolymph) trapped on FTA cards, the presence of prepatent stages of *S. haematobium* in *B. globosus* was detected by two PCR assays (DraI PCR and Sh110/Sm-SI PCR) using primers according to Amarir *et al.* (2014). These reactions, which enabled differentiation of *Schistosoma haematobium* DNA from DNA of related *Schistosoma* spp. (*e.g., S. bovis*, which is sympatric with *S. haematobium* in many endemic areas), revealed infected snails also at the river Buburu, Mbararani, Kiwumiro and Bangoni.

The results of our study indicate that the treatment strategy focusing only on MDA to school age children cannot interrupt the transmission of the disease. Since most affected people live in

simple dwellings without running water, they will inevitably come into contact with water contaminated by cercariae when bathing, washing clothes or watering animals. Recently, therefore, many authors have emphasized the need for integrated control measures, including regulation of the number of intermediate hosts, access to clean water and health education as a complement to MDA (Sokolow, 2016; Ross, 2017). Furthermore, the World Health Assembly (WHA) in its resolution called for the implementation of complementary, non-pharmaceutical control strategies to eliminate this disease (WHA, 2012).

In conclusion, schistosomosis was still present in the study area, although the majority of positive participant had light form of infection. Transmission of diseases was not interrupted and continued to take place in some areas of reasearch. The rate of infection was significantly influenced by type of housing and water supplies used for indoor and outdoor household purposes. Preventive measures should consider that MDA to school children as well as implementation of adequate water supply, sewage system, sanitation facilities and health education could have positive impact on the control of schistosomosis.

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Conflict of Interest

Authors have no potential conflict of interest pertaining to this submission to Helminthologia.

References

Adenowo, A.F., Oyinloye, B.E., Ogunyinka, B.I., Kappo, A.P. (2015): Impact of human schistosomiasis in sub-Saharan Africa. *Braz. J. Infect. Dis.,* 19(2): 196 – 205. DOI: 10.1016/j.bjid.2014.11.004

Amarir, F., Sebti, F., Abbasi, I., Sadak, A., Fellah, H., Nhammi, H., Ameur, B., El Idrissi, A.L., Rhajaoui, M. (2014): Schistosoma haematobium detection in snails byDraI PCR and Sh110/Sm-SI PCR: Further evidence of the interruption of schistosomiasis transmission in Morocco. *Parasit Vectors*., 7. DOI:10.1186/1756-3305-7-288

Anosike, J.C., Nwoke, B.E.B., Njoku, A.J. (2001): Validity of haematuria in the community diagnosis of urinary schistosomiasis infection. *J. Helminthol.,* 75(3): 223 – 225. DOI: 10.1079/JOH200048

Brooker, S. (2002): Schistosomes, snails and satellites. *Acta Trop.*, 82(2): 207 – 214. DOI: 10.1016/S0001-706X(02)00012-8

Bruun, B., Aagaard-Hansen, J. (2008):*The social context of schistosomiasis and its control: an introduction and annotated bibliography*. 1st Edition, Geneva, Switzerland, World Health Organization, 213 pp.

Bustinduy, A.L., Parraga, I.M., Thomas, C.L., Mungai, P.L., Mutuku, F., Muchiri, E.M., Kitron, U., King C.H. (2013): Impact of polyparasitic infections on anemia and undernutrition among Kenyan children living in a Schistosoma haematobium-endemic area. *Am. J. Trop. Med. Hyg.*, 88(3): 433–40. DOI: 10.4269/ajtmh.12-0552

Chadeka, E., Nagi, S., Sunahara, T., Cheruiyot, N., Bahati, F., Ozeki, Y., Inoue, M., Osada-Oka, M., Okabe, M., Hirayama, Y., Changoma, M., Adachi, K., Mwende, F.,Kikuchi, M., Nakamura, R., Kalenda, Y., Kaneko, S., Hirayama, K., Shimada, M., Ichinose, Y., Njenga, S., Matsumoto, S., Hamano, S. (2017): Spatial distribution and risk factors of Schistosoma haematobium and hookworm infections among schoolchildrenin Kwale, Kenya. *PLoS Negl. Trop. Dis.,* 11(9): e0005872. DOI: 10.1371/ journal.pntd.0005872

Clennon, J.A., Mungai, P.L., Muchiri, E.M. , King, C.H., Kitron, U.(2006): Spatial And TemporalVariations In Local Transmission Of Schistosoma Haematobium In Msambweni, Kenya. *Am. J. Trop. Med. Hyg. ,* 75(6): 1034 – 1041. DOI: 10.4269/ajtmh.2006.75.1034

Ekpo, U., Alabi, O., Oluwole, A. , Sam-Wobo, S. (2012): Schistosoma haematobium infections in preschool children from two rural communities in Ijebu East, south-western Nigeria. *J. Helminthol*., 86(3): 323 – 328. DOI: 10.1017/S0022149X11000459

El Ridi, R.A., Tallima, H.A. (2013): Novel therapeutic and prevention approaches for Schistosomiasis: Review. *J. Adv. Res.,* 4(5): 467 – 478. DOI: 10.1016/j.jare.2012.05.002

French, M., Rollinson, D., Basáñez, M., Mgeni, A., Khamis, I., Stothard, J.(2007):School-based control of urinary schistosomiasis on Zanzibar, Tanzania: Monitoring micro-haematuria with reagent strips as a rapid urological assessment. *J. Pediatr. Urol.,* 3(5): 364-368. DOI: 10.1016/j.jpurol.2007.01.198

Grimes, J.E., Croll, D., Harrison, W.E., Utzinger, J., Freeman, M.C., Templeton, M.R. (2014): The Relationship between Water, Sanitation and Schistosomiasis: A Systematic Review and Meta-analysis. *PLoS Negl. Trop. Dis*., 8(12): e3296. DOI:10.1371/ journal.pntd.0003296

Gryseels, B., Polman, K., Clerinx, J., Kestens, L. (2006): Human schistosomiasis. *Lancet*, 368(9541): 1106 – 1118. DOI: 10.1016/ S0140-6736(06)69440-3

Houmsou, R., Kela, S., Suleiman, M. (2011): Performance of microhaematuria and proteinuria as measured by urine reagent strips in estimating intensity and prevalence of *Schistosoma haematobium* infection in Nigeria. *Asian. Pac. J. Trop. Dis.*, 4(12):997-1000. DOI: 10.1016/S1995-7645(11)60233-2

Kayuni, S., Peeling, R., Makaula, P. (2017): Prevalence and distribution of *Schistosoma haematobium* infection among school children living in southwestern shores of Lake Malawi. *Malawi Med. J.,* 29(1):16 – 23. DOI: 10.4314/mmj.v29i1.4

Kholy, H.E., King, C.H., Koech, D., Sturrock, R.F., Siongok, T.K., Mahmoud, A.A., Houser, H. (1989): Effects of Borehole Wells on Water Utilization in *Schistosoma haematobium* Endemic Communities in Coast Province, Kenya. *Am. J. Trop. Med. Hyg.*, 41(2): 212 – 219. DOI:10.4269/ajtmh.1989.41.212

King, C., Bertsch, D. (2013): Meta-analysis of Urine Heme Dipstick Diagnosis of *Schistosoma haematobium* Infection, Including Low-Prevalence and Previously-Treated Populations. *PLoS Negl. Trop. Dis.*, 7(9):e2431. DOI: 10.1371/journal.pntd.0002431

King, C.H., Lombardi, G., Lombardi, C., Greenblatt, R., Hodder, S., Kinyanjui, H., Ouma, J., Odiambo, O., Bryan, P.J., Muruka, J.(1988): Chemotherapy-based control of schistosomiasis haematobia. I. Metrifonate versus praziquantel in control of intensity and prevalence of infection. *Am. J. Trop. Med. Hyg*., 39(3): 295-305. DOI: 10.4269/ajtmh.1988.39.295

Knopp, S., Ame, S., Hattendorf, J., Ali, S., Khamis, I., Bakar, F., Khamis, M., Person, B., Kabole, F., Rollinson, D. (2018):Urinary schistosomiasis elimination in Zanzibar: accuracy of urine filtration and haematuria reagent strips for diagnosing light intensity *Schistosoma haematobium* infections. *Parasit. Vectors*, 11. DOI: 10.1186/s13071-018-3136-6

Krauth, S., Greter, H., Stete, K., Coulibaly, J., Traoré, S., Ngandolo, B., Achi, L., Zinsstag, J., N'goran, E., Utzinger, J. (2015): All that is blood is not schistosomiasis: experiences with reagent strip testing for urinary schistosomiasis with special consideration to very-low prevalence settings. *Parasit. Vectors*, 8.DOI: 10.1186/s13071-015-1165-y

Meurs, L., Mbow, M., Boon, N., Van Den Broeck, F., Vereecken, K., Dièye, T., Abatih, E., Huyse, T., Mboup, S., Polman, K. (2013): Micro-Geographical Heterogenity in *Schistosoma mansoni* and *S. haematobium* Infection and Morbidity in a Co-Endemic Community in Northern Senegal. *PLoS Negl. Trop. Dis.*, 7(12):e2608. DOI: 10.1371/journal.pntd.0002608

Mutuku, F., Bustinduy, A., King, C., Kitron, U., Muchiri, E., Mungai, P. (2011): Impact of Drought on the Spatial Pattern of Transmission of *Schistosoma haematobium* in Coastal Kenya. *Am. J. Trop. Med. and Hyg.*, 85(6): 1065 – 1070. DOI: 10.4269/ajtmh.2011.11-0186

Muhumuza S., Olsen A., Katahoire, A., Kiragga, A.N., Nuwaha, F. (2014): Effectiveness of a pre-treatment snack on the uptake of mass treatment for schistosomiasis in Uganda: A cluster randomized trial. *PLoS Med.*, 11(5): e1001640. DOI: 10.1371/journal.pmed.1001640

Njenga, S.M., Mutungi, F.M., Wamae, C.N., Mwanje, M.T., Njiru, K.K., Bockarie, M.J. (2014): Once a year school-based deworming with praziquantel and albendazole combination may not be adequate for control of uro genital schistosomiasis and hookworm infection in Matuga District, Kwale County, Kenya. *Parasit. Vectors*, 7.DOI: 10.1186/1756-3305-7-74

N'goran, E.K., Gnaka, H.N., Tanner, M., Utzinger, J. (2003): Efficacy and side-effects of two praziquantel treatments against *Schistosoma haematobium* infection, among school children from Côte d'Ivoire. *Ann. Trop.Med. Parasitol*., 97(1): 37–51. DOI: 10.1179/000349803125002553

Nkegbe, E. (2010): Sex prevalence of schistosomiasis among school children in five communities in the lower river Volta basin of South Eastern Ghana. *Afr. J. Biomed. Res.,*13: 87–88.

Ochodo, E.A., Gopalakrishna, G., Spek, B., Reitsma, J.B., Van Lieshout, L., Polman, K., Lamberton, P., Bossuyt, P.M., Leeflang, M.M. (2015): Circulating antigen tests and urine reagent strips for diagnosis of active schistosomiasis in endemic areas. *Cochrane Database Syst. Rev*., (3): 1 – 292. DOI:10.1002/14651858.CD009579.pub2

Ross, A.G., Chau, T.N., Inobaya, M.T., Olveda, R.M., Li, Y., Harn, D.A. (2017): A new global strategy for the elimination of schistosomiasis. *Int. J. Infect. Dis*., 54: 130–137. DOI:10.1016/j.ijid.2016.09.023

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(8): e2377.DOI:10.1371/journal.pntd.0002377

Sato, K., Shimada, M., Noda, S., Muhoho, N.D., Katsumata, T., Sato, A., Aoki, Y. (1988): Efficacy of metrifonate in a highly endemic area of urinary schistosomiasis in Kenya. *Am. J. Trop. Med. Hyg*., 38(1): 81-5. DOI: 10.4269/ajtmh.1988.38.81

Singh, K., Muddasiru, D., Singh, J. (2016): Current status of schistosomiasis in Sokoto, Nigeria. *Parasite Epidemiol. Control*, 1(3): 239 – 244. DOI: 10.1016/j.parepi.2016.08.003

Sokolow, S.H., Wood, C.L., Jones, I.J., Swartz, S.J., Lopez, M., Hsieh, M.H., Kevin, D., Lafferty, K.D., Kuris, A.M., De Leo, G.A. (2016): Global Assessment of Schistosomiasis Control Over the Past Century Shows Targeting the Snail Intermediate Host Works Best. *PLoS Negl. Trop. Dis.*, 10(7):e0004794 DOI:10.1371/journal.pntd.0004794

Ximenes, R., Southgate, B., Smith, P.G., Neto, L.G. (2003): Socioeconomic determinants of schistosomiasis in an urban area in the Northeast of Brazil. *Rev. Panam. Salud. Publica,* 14(6): 409-421.

WHA (2012): Elimination of schistosomiasis. Geneva: WHO: WHA65/2012/REC/1Sixty-fifth World Health Assembly: resolutions and decisions annexes