Human water contact patterns in active schistosomiasis endemic areas

O. G. Oso and A. B. Odaibo

ABSTRACT

One major risk factor common to individuals in schistosomiasis endemic areas is water contact patterns. Effort to determine the dynamics in water contact patterns in different regions needs utmost attention in order to suggest a better control strategy for schistosome infection. Quantitative observations on human water contact activities were recorded in Yewa North Local Government Area of Ogun State for a period of two years. Frequency and duration of observed water contact activities were recorded. Males had the highest water contact during the rainy season with 51.1% compared to females with 48.9%. Females had the highest water contact with 51.0% while males had 49.0% during the dry season. The age group 10–19 years had the highest water contact with 27.1%, this was followed by 20–29 years and 30–39 years age groups with 23.6% and 22.1%, respectively, during the rainy season. Our results showed that water contact activities differ with respect to different communities, sex and age groups. Previous high prevalence of schistosome infection in the study areas could be attributed to high water contact activities. Therefore, provision of adequate pipe-borne water, good sanitation and improved knowledge on schistosome life cycle among the community members will reduce the high rate of human water contacts.

Key words | duration, frequency, schistosomiasis, water contact

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HIGHLIGHTS

- It provides risk factor associated with schistosome infection.
- It provides suggestion on how to reduce the infection in rural areas.
- It gives an overview of up-to-date review of the infection.
- It provides an up-to-date map of the study areas.

INTRODUCTION

Infections associated with water contact, either by drinking or water usage are cosmopolitan, most especially in developing countries. Diseases linked to drinking contaminated water include cholera, typhoid, crytosporidiosis among others, while other water-related parasitic diseases which require a vector or an intermediate host for their transmission include paragonimiasis, dracunculiasis, clonorchiasis and schistosomiasis. All these diseases are potential causes of morbidity and mortality in humans (Clasen *et al.* 2007; Nwabor *et al.* 2016).

Schistosomiasis ranks second only to malaria among the parasitic diseases with regards to the number of people infected and those at risk. According to previous estimates, the disease causes the annual loss of between 1.7 and 4.5 million disability adjusted life years (DALYs) (WHO 2002; Utzinger & Keiser 2004; Alemu *et al.* 2018). Most of the schistosomiasis burden is concentrated in sub-Saharan Africa (Chitsulo *et al.* 2000) with the highest prevalence and infection intensities usually found in school-age children, adolescents and young adults (Jordan *et al.* 1993;

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Woolhouse 1998). Human hosts release eggs into fresh water when they urinate or defecate. In fresh water, eggs are shed and under favourable environmental conditions, miracidia are released from the eggs, which swim and penetrate specific snail intermediate hosts. Intramolluscan developmental stages occur in the snail and they shed hundreds of cercariae into the environment. Infections in humans occur when they have contact with infested fresh water (Mouahid *et al.* 2018; Viana *et al.* 2018). The only drug of choice that is effective for the treatment of schistosomiasis is praziquantel. A single dose of 40 mg/kg of paraziquantel is recommended for infected individuals (Hassan *et al.* 2012; Zwang & Olliaro 2014). The availability of pipe-borne water, sanitation, vector/snail intermediate control and the right health education on the life cycle of the disease has been proven to control the spread of many diseases that are associated with water usage (Chala & Torben 2018).

In Nigeria, one of the most severely affected countries in Africa, it is estimated that 101.28 million people are at risk of infection while 25.83 million are infected with *Schistosoma haematobium*, *Schistosoma mansoni* and *Schistosoma intercalatum* (Chitsulo *et al.* 2000). There are three main species of schistosomes infecting humans, *S. mansoni* and *Schistosoma japonicum* which inhabit the mesenteries around the intestine causing intestinal schistosomiasis and *S. haematobium*, which is found in the venules surrounding the bladder causing urinary schistosomiasis. Both *S. mansoni* and *S. haematobium* are endemic in Nigeria, with the latter being more widely distributed. *S. haematobium* is known to be transmitted by the planorbid snail *Bulinus* species, including *B. globosus*, *B. africanus*, *B. nasutus* and *B. truncatus*. Also, *B. forskalii* and *B. senegalensis* have been incriminated as intermediate hosts of *S. haematobium* (Betterton *et al.* 1983; Ugbomoiko 2000; Anosike *et al.* 2001) and *Biomphalaria pfeifferi*, the intermediate host of *S. mansoni*. Some studies carried out in the area observed high prevalence of the disease in preschool children, school children and pregnant women (Hassan *et al.* 2012; Salawu & Odaibo 2013, 2014); moreover, after treatment of these sets of individuals, re-infection with schistosoma parasites still occurred. Clinical manifestations of the disease include dysuria (painful urination), haematuria (blood in the urine) or blood in stools. Other manifestations are genital tract infections, bladder cancer, hepatomegaly, constipation and diarrhoea (Nelwan 2019). The study, therefore, aims to assess human water contact patterns in order to map out possible control measures in the study areas.

MATERIALS AND METHODS

Study areas

Yewa North Local Government Area (YNLGA) is located close to the Republic of Benin. It has several villages with headquarters in Ayetoro. Other local government areas surrounding YNLGA include Imeko-Afon, Yewa South, Abeokuta North and Ewekoro (Figure 1). One of the largest cement factories is located in YNLGA. Other mineral deposits include gold, gypsum, clay, phosphate, diamond, tin and uranium. We obtained informed consent from village heads and the State Ministry of Health before commencement of the study.

Data collection

Direct observations of individual water contacts were carried out for 24 months, as described by Ofoezie *et al.* (1991). The study duration of 24 months was used in order to monitor the differences of human water contact for two seasons. The sites selected for the study were the main water contact sites in different villages where most activities leading to schistosome infection occurred (Figure 2). The water contact behaviour of the inhabitants of Yewa was observed from 8 a.m. until 4 p.m., once in each month. Each individual entering the water was identified by the observer and recorded in a notebook by age, sex, type of water contact activity, time of entrance into, and exit out of the water. Four different types of activities were recorded: (a) washing; (b) fetching; (c) swimming; (d) fishing. The data were entered daily into a Microsoft Excel spreadsheet and extensively checked for errors before analysis.

Data analysis

Frequency and duration of water contact were considered for analysis. Frequency was defined by the number of

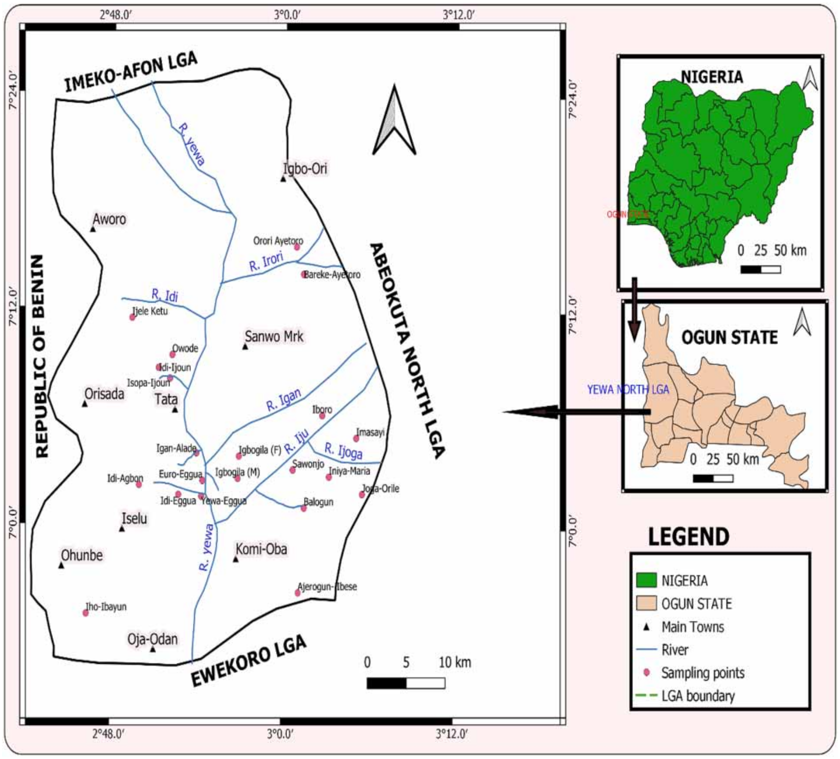

Figure 1 | Map of Yewa North LGA, showing study areas.

Figure 2 | Water contact activities at Ikiso River.

water contacts, irrespective of the (type of) activity. Table 1 lists the single and combined activities which were used to determine frequencies. Duration was defined by the time spent in the water during a water contact activity. Frequencies and durations of water contact data were further categorized per age group (0–9 years, 10–19 years, 20–29 years, 30–39 years, 40–49 years, 50–59 years and >60 years old) and sex. They were divided according to season (rainy and dry), time and type of activity.

RESULTS

The frequency and duration of the observed water contact activities in the study communities are presented in Table 1. Out of a total of 13,800 contacts with a duration of 187,010 minutes, Idi River (Ijoun) had 1,729 (12.5%) contacts and 25,265 (13.5%) minutes' duration followed by Ikiso River (Sawonjo) with 1,591 (11.5%) contacts and 21,833 (11.7%) minutes' duration. Balogun River had the least with 78 (0.6%) and 936 (0.5%) contacts and duration, respectively. However, there was a significant difference ($P < 0.05$) in the variables between the communities.

Both males and females participated in the water contact activities; however, some activities exhibited a distinct gender-related pattern. Male water contact with 50.2% was

Table 1 | Frequency and duration (minutes) of water contacts in Yewa North communities

Water contact sites	Total contact/frequency[a]	Total duration[α]	GPS location
Bareke Ayetoro	749 (5.4)	14,682 (7.9)	3.20013E/7.21065N
Orori Ayetoro	946 (6.9)	15,658 (8.4)	3.02365E/7.24768N
Ikiso Sawonjo	1,591 (11.5)	21,833 (11.7)	3.01121E/7.08569N
Iju Iboro	421 (3.1)	7,038 (3.8)	3.08405E/7.09064N
Iju Joga Orile	502 (3.6)	9,040 (4.8)	3.12022E/7.11696N
Iju Imasayi	665 (4.8)	11,037 (5.9)	3.07686E/7.08135N
Iniya Maria	217 (1.6)	3,424 (1.8)	3.05369E/7.05369N
Ajerogun Ibese	202 (1.5)	1,861 (1.0)	3.02017E/6.95877N
Balogun	78 (0.6)	936 (0.5)	3.03026E/7.04044N
Iju Igbogila (M)	683 (4.9)	9,551 (5.1)	2.98452E/7.04719N
Iju Igbogila (F)	449 (3.3)	4,476 (2.4)	2.98322E/7.04776N
Euro Eggua	172 (1.2)	2,081 (1.1)	2.90514E/7.01657N
Yewa Eggua	753 (5.5)	6,102 (3.3)	2.90978E/7.04871N
Iho Ibayun	604 (4.4)	5,524 (3.0)	2.72449E/6.94370N
Idi Agbon	558 (4.0)	5,179 (2.8)	2.83273E/7.03075N
Idi Eggua	654 (4.7)	6,343 (3.4)	2.90254E/7.04902N
Yewa Igan Alade	782 (5.7)	9,740 (5.2)	2.90699E/7.05624N
Yewa Owode	296 (2.1)	4,293 (2.3)	2.89299E/7.12500N
Idi Ijale Ketu	624 (4.5)	5,615 (3.0)	2.82386E/7.19132N
Isopa Ijoun	1,729 (12.5)	25,265 (13.5)	2.84737E/7.14880N
Idi Ijoun	1,125 (8.2)	17,332 (9.3)	2.85965E/7.13849N
Total	**13,800 (100)**	**187,010 (100)**	

[a]Figures in parentheses indicate percentage of total.

a little higher than female water contact with 49.8%. However, this slight difference in frequency was significant ($x^2 = 13{,}057.99$, $P < 0.05$). Generally, males also had a higher duration of water contact compared to females, and the difference was also significant ($P < 0.05$). The relative exposure index of males was significantly higher compared to females ($P < 0.05$) (Table 2). The age-related pattern of water contact in the study sites is shown in Figure 3 while their mean duration is shown in Table 3. The age group 10–19 years had the highest water contact while the least water contact was found in the age group above 60 years. The highest frequency of individual water contact occurred in the month of March of the second season (Figure 4). Multivariate analysis showed significant difference ($P < 0.05$) among age group and water contact activities in the study areas.

Although the rainy season recorded more water contact compared to the dry season (Figure 5), there was no significant difference ($P > 0.5$) in the seasonal pattern of water contact frequency and duration throughout the study period. Males had the highest water contact during the rainy season with 51.1% compared to females with 48.9% (Table 4). However, during the dry season, females had the highest water contact with 51.0% while males had 49.0%. The 10–19 years age group had the highest water contact with 27.1%, closely followed by the 20–29 years and 30–39 years age groups with 23.6% and 22.1%, respectively, and during the rainy season (Figure 6); however, the 20–29 years age group had the highest duration (Table 5). In addition, during the dry season, the 10–19 years age group had 26.7% while the 20–29 years and 30–39 years age groups had 22.4% and 23.0%, respectively.

Table 2 | Water contact patterns in relation to exposure index and sex in Yewa North LGA

	Total			Male			Female		
Water contact activities	**Frequency of exposure**	**Exposure index**	**% exposure**	**Frequency of exposure**	**Exposure index**	**% exposure**	**Frequency of exposure**	**Exposure index**	**% exposure**
Fetching	3,829	11,487	21.50	1,341	4,023	13.96	2,488	7,464	30.34
Washing	3,903	11,709	21.92	1,522	4,566	15.84	2,381	7,143	29.03
Swimming	6,012	30,060	56.27	4,018	20,090	69.71	1,994	9,970	40.52
Fishing	56	168	0.31	47	141	0.49	9	27	0.11
Total exposure	**13,800**	**53,424**	**100**	**6,928**	**28,820**	**100**	**6,872**	**24,604**	**100**

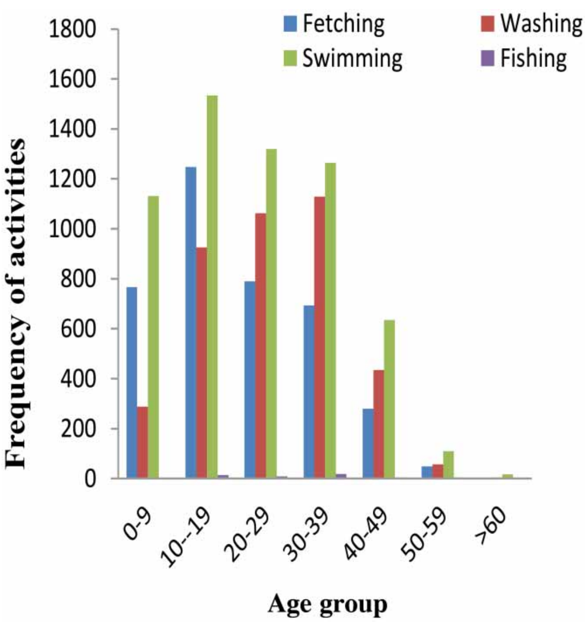

Figure 3 | Water contact activities in relation to age group in Yewa North LGA.

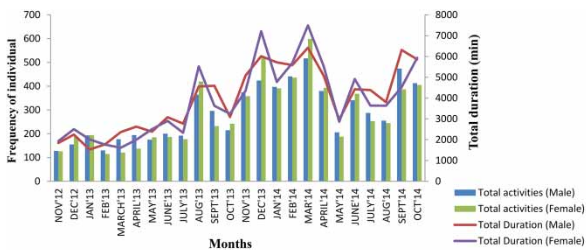

Figure 4 | Monthly variation in water contact patterns in Yewa North LGA.

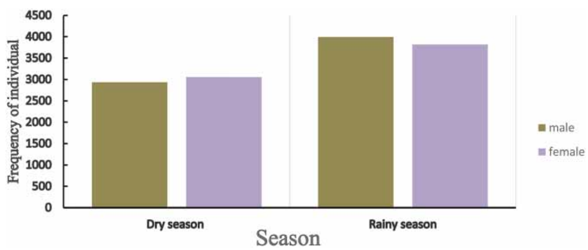

Figure 5 | Variation in frequency of human water contact and sex in first and second seasons.

Table 3 | Mean duration (minutes) of each water contact activity in relation to age and sex

Activities	Fetching		Washing		Swimming		Fishing	
Age group (years)	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**
0–9	1.4	1.5	20.7	18.7	15.0	15.6	26.0	0.0
10–19	1.3	1.3	18.4	19.5	15.6	16.2	27.4	28.3
20–29	1.3	1.3	23.9	25.6	14.0	14.6	27.3	26.0
30–39	1.0	1.0	28.6	28.3	11.4	11.9	27.8	0.0
40–49	1.2	1.1	30.3	31.5	11.5	11.8	26.2	0.0
50–59	1.2	1.1	21.4	26.0	12.5	11.8	21.7	27.0
>60	0.0	1.7	38.0	31.5	13.3	13.3	28.0	0.0

DISCUSSION

The main risk factors associated with the endemicity of urinary schistosomiasis in different areas are low literacy, intermediate snail host, presence of infested water bodies like streams, ponds and closeness of infested water to school/residential areas where daily activities like washing, fetching of water for domestic purposes, fishing, bathing and swimming take place (Ofoezie 1999; Mbata *et al.* 2009; Getachew *et al.* 2014). Different methods have been used for assessing human exposure to water bodies, the most common being self-reported exposure questionnaires and

Table 4 | Frequency of water contact, duration (minutes) and sex in first and second seasons

	First season		Second season	
Sex	Dry season No. of contact (duration)[a]	Rainy season No. of contact (duration)[a]	Dry season No. of contact (duration)[a]	Rainy season No. of contact (duration)[a]
Male	783 (9,756)	1,636 (23,098)	2,153 (28,815)	2,356 (32,829)
Female	744 (9,824)	1,580 (22,126)	2,309 (29,511)	2,239 (31,051)
Total	1,527 (19,580)	3,216 (45,224)	4,462 (58,326)	4,595 (63,880)

[a]Unit of duration is minutes.

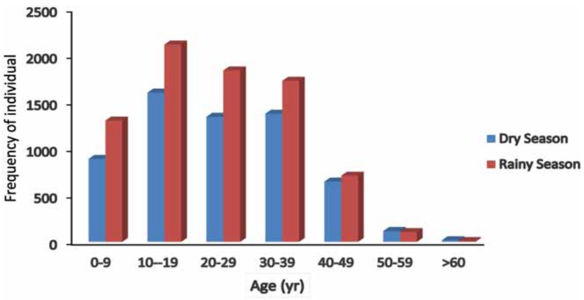

Figure 6 | Seasonal variation in age groups and frequency of water contact in Yewa North LGA.

direct observation (Kloos *et al.* 1983, 1997; Lima e Costa *et al.* 1987; Chandiwana & Woolhouse 1991; Fulford *et al.* 1996; da Silva *et al.* 1997; Ross *et al.* 1998a, 1998b; Kabatereine *et al.* 1999; Li *et al.* 2000; Bethony *et al.* 2001; Gazzinelli *et al.* 2001; Scott *et al.* 2003; Spear *et al.* 2004).

The direct observation method used during this study recorded more water contacts than similar studies in Africa (Sama & Ratard 1994; Noda *et al.* 1997) and Brazil (Silva 1985; Lima e Costa *et al.* 1987; Gazzinelli *et al.* 2001). There was a significant difference observed in this study with respect to gender, and this result was in agreement with that of Gazzinelli *et al.* (2001). Domestic activities performed by females were of shorter duration and involved less immersion of the body in water than for males. Similar results were reported in Mauritania and Nigeria (Etard & Borel 1992; Iwu *et al.* 2015). However, it differs from the results obtained by Akogun & Akogun (1996), Okoli & Odaibo (1999) and Ukpai & Ezeike (2002). The non-significant difference for seasonal water contact is an indication that water usage pattern remains unaffected throughout the year. This may be as a result of limited pipe-borne water in most of the communities. Besides, this limited pipe-borne water does not easily lather with soap while some think it is more convenient to wash utensils and agricultural produce in a flowing river compared with using

Table 5 | Frequency of water contact, duration (minutes) in relation to age groups in first and second seasons

	First season		Second season	
Age (years)	Dry season No. of contact (duration)[a]	Rainy season No. of contact (duration)[a]	Dry season No. of contact (duration)[a]	Rainy season No. of contact (duration)[a]
0–9	180 (1,990)	506 (5,271)	709 (7,510)	795 (9,322)
10–19	584 (5,297)	908 (11,195)	1,018 (11,935)	1,211 (15,480)
20–29	255 (4,324)	729 (11,238)	1,087 (15,172)	1,111 (15,644)
30–39	325 (5,109)	744 (12,620)	1,051 (14,745)	985 (15,391)
40–49	139 (2,273)	273 (4,117)	507 (7,619)	436 (7,374)
50–59	37 (508)	49 (688)	79 (1,124)	56 (641)
>60	7 (79)	7 (95)	11 (221)	1 (28)
Total	**1,527 (19,580)**	**3,216 (45,224)**	**4,462 (58,326)**	**4,595 (64,880)**

[a]Unit of duration is minutes.

pipe-borne water or well water. Males who engage in agricultural activities throughout the year often find solace in bathing in the nearest water bodies before getting to their different destinations.

The highest water contact was observed in Ijoun (Isopa River), and was closely followed by water contact in Ikiso River in Sowonjo community. The high water contact in Sawonjo was as a result of washing of farm produce by young pupils from the nearby primary school as well as the presence of young adult farmers in the community, while in Isopa River, washing of clothes was one of the major water contact activities in the area. The least water contact frequency, recorded in Balogun, was due to the location of the water body in a farm settlement, hence, only a few farmers wade into the water shortly after their farming activities. Orori River had more males who engaged in washing vehicles and motor cycles, however, in Bareke River, more females were involved in washing locust beans and other farm produce, hence, the variation in the gender water contact patterns in these areas. Easy access and proximity to water bodies was one of the major factors that contributed to the risk of schistosome infection (Getachew *et al.* 2014). Isopa and Idi Rivers were located in Ijoun community. Idi River had few water contacts while Isopa River had more water contact. The high frequency of water contact in Isopa River could be attributed to the closeness of the river to the community compared with Idi River which was farther from the community. The same pattern was also observed in Eggua community. Yewa River was closer to the community compared to Euro River which was farther from the community. A similar observation was reported in Egypt, Kenya and Brazil, where both manual and geographic information systems were used to monitor water contact patterns in these countries (Kloos *et al.* 1998).

In all, it was observed that the age group of 10–19 years had the highest water contact throughout the study period. Different studies have related the age distribution with infection status in Nigeria as well as countries where schistosomiasis is endemic. In Nigeria, individuals between the ages of 10 and 20 years have more contact with infested water, hence, the high prevalence of infection in this age group (Okoli & Odaibo 1999; Bello *et al.* 2003; Okanla *et al.* 2003; Anosike *et al.* 2006; Houmsou *et al.* 2012); a similar result was also obtained in Ghana and Cameroon (Okanla *et al.* 2003; Same *et al.* 2007). Among all the water contact activities, swimming accounts for the highest frequency. Swimming is known to play a significant role in risk of schistosome infection (Houmsou *et al.* 2012). Some studies have reported that there is no significant difference in schistosome infection due to gender and the reason has been attributed to variations in some cultural and behavioural practices in relation to water contact patterns (Udonsi 1990; Verle *et al.* 1994; Anosike *et al.* 2006; Emejelu *et al.* 2006; Aboagye & Edoh 2009; Hassan *et al.* 2012). However, prevalence of schistosomiasis had been found to be higher in males than in females (Odaibo *et al.* 2004; Uneke *et al.* 2007; Agi & Awi-waadu 2008; Sulyman *et al.* 2009; Houmsou *et al.* 2012) while Etim (1998) reported that prevalence of infection was higher in females than in males. In this study, males had significantly higher frequency of water contact than females. Hence, it is expected that schistosome infection could be higher in males compared to females in the study areas.

According to our observations, high water contact activities occurred in sample stations that were closer to the villages compared with sampling sites that were far away from the villages. Thus, those villages that are closer to water contact sites are more prone to schistosome infection. Therefore, the provision of adequate alternative water supply should be made available in different villages in order to reduce human water contact with infested water bodies. Modifying the natural environment of the snail intermediate hosts will, in turn, change the ecology of the habitats, thereby preventing further snail breeding and make the environment less habitable for the snail intermediate hosts (Jordan *et al.* 1993). This can be achieved by constant removal of vegetation, elimination of pools and increasing the velocity of water in order to prevent breeding of the amphibious snail species. In addition, the introduction of natural enemies of snails, e.g., predators, competitors of undesired species, will also reduce snail intermediate hosts (Yang *et al.* 2014). Molluscicides of either plant origin or synthetic have also been effective in controlling snail intermediate hosts (Sundaraneedi *et al.* 2017). In most cases, successful molluscicides must be effective at low concentrations, have low toxicity to non-target organisms with high specificity to snails, be an attracting agent to the snails, have stable formulation under different environmental applications and storage conditions, non-toxic to man, must not produce unacceptable adverse effects if they enter the food chain, easy to apply in the field, stable in storage and in the habitat after application and should be relatively cheap.

CONCLUSION

We therefore conclude that provision of adequate pipe-borne water, good sanitation and improved knowledge on schistosome life cycle among the community members will lead to reduction in human water contacts; this will eventually reduce schistosome infection in the communities. Governments at all levels are encouraged to provide alternate sources of water for recreational purposes.

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DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

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