Distribution and Factors Associated With Urogenital Schistosomiasis in Tiko Health District, A Semi-urban Setting, South West Region, Cameroon

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Abstract

Background: Increased risk of schistosomiasis in peri-urban and urban towns is not uncommon. An epidemiological survey was carried out in the Tiko Health District (THD), an unmapped transmission focus for urogenital schistosomiasis (UGS), to assess the distribution, intensity and risk factors associated with the occurrence of UGS in the District.

Methods: In this cross-sectional survey, 1029 individuals were enrolled from twelve communities purposively selected from four health areas (Likomba, Holforth, Holforth-Likomba and Mutengene) between June and August 2018. A semi-structured questionnaire was used to collect information on sociodemographic and water contact behaviour. Urine samples were examined for *S. haematobium* infection using test strip, filtration and microscopy methods. Bivariate and binary logistic regression analyses were used to identify predictors of infection.

Results: The overall prevalence of UGS in the Likomba, Holforth-Likomba and Holforth was 31.5% (95% CI: 28.3 – 34.8). *Schistosoma haematobium* infection was not found in Mutengene HA. Infection was unevenly distributed among the HAs, Holforth-Likomba and Holforth being the most and least affected, respectively. The prevalence of infection varied ($p < 0.001$) among the affected communities, ranging from 0 – 56.9%. Infection status of the community related positively ($p < 0.001$) with proximity to stream (< 100m), the degree of contact (II) with water and number of improved water sources. Younger age group (5 – 14 years) (aOR = 3.6, 95% CI: 1.1 – 12.0) and intense water contact (Degree II) (aOR = 5.2, 95% CI: 3.4 – 8.1) were associated with increased risk of infection as well as higher worm egg load excretion.

Conclusion: Generally, THD is a moderate risk endemic focus for UGS but prevalence higher than 50% was observed in some communities. These findings warrant immediate mass chemotherapy with praziquantel to reduce morbidity. Provision of portable water and health education are proposed measures to reduce and eventually eliminate transmission in the area.

Background

Schistosomiasis is the third highest burden among the Neglected Tropical diseases (NTDs) and is endemic in 78 countries worldwide where an estimated 800 million people are at risk of the disease. Of the 250 million infected individuals, 200 million live in Africa where the two predominant disease sub-types are intestinal and urogenital schistosomiasis caused by *Schistosoma mansoni* and *S. haematobium*, respectively [1, 2]. Globally, an estimated 1.43 million disability-adjusted life years (DALYs) is lost to schistosomiasis [3]. Over 150 000 deaths are attributable to chronic infection with *S. haematobium* in Africa [4, 5].

The transmission of schistosomiasis is governed by social-ecological systems such as conditions of poverty and living near open freshwater bodies [6]. Children are at a greater risk of acquiring the infection as well as re-infection [7], and this might lead to growth retardation, anaemia and low school performance [8]. Nonetheless, in endemic areas, where there is lack of adequate water supply, poverty, ignorance and poor hygienic practices, any demographical groups, irrespective of age or gender with unsafe water contact is at risk of infection [9]. The current mainstay of schistosomiasis control is preventive chemotherapy - the periodic administration of praziquantel to at-risk groups (e.g., school-age children). While this strategy does not prevent infection or reinfection, it reduces morbidity and might also impact on transmission [10]. Schistosomiasis can be prevented by avoiding contact with contaminated freshwater, and the risk of infection can be reduced through improved access to water, sanitation, and hygiene (WASH), information, education, and communication (IEC) [11].

Although schistosomiasis is classically described as a rural disease that occurs in areas without potable water and adequate sanitation [12], urban foci of parasites in tropical areas can no longer be ignored [13]. Increased risk of schistosomiasis in urban areas has been linked to migration of people to neighbouring towns for more attractive employment opportunities [12, 14], water resource development to curb inadequacy in water supply [15] and small multipurpose dams that may lead to ecological changes [17, 16]. Outbreak of neglected tropical diseases in urban areas has been reported due to rapid urbanization which at the same time can also fail to sustain healthy populations when it surpasses clean water reserve and sewage management systems [18]. More so, in this era of global warming and climatic change, the epidemiology of temperature dependent infectious diseases is rapidly changing [15].

In the South West Region of Cameroon, records of urogenital schistosomiasis are mostly from rural areas [7, 19–22]. An unmapped transmission focus has been reported in peri-urban communities in the THD [23]. It remains unknown whether UGS has existed in the THD for an undetermined period or has recently been introduced. In low and middle-income countries experiencing urbanization, the problem of access to water and sanitation is more critical in secondary cities because of the lower basic infrastructure compared with the situation in the primary cities [17]. Inadequate water supply and sanitation have been reported as a major concern in the THD [24] and in addition to extensive rural-urban migration probably due to interurban trading or political unrest in the English-speaking part of Cameroon [25], transmission intensity of UGS may be exacerbated in this peri-urban setting. The previous survey conducted in this new focus was geographically limited to a single community and involved only children aged 5–20 years [23]. In addition, a less sensitive method (urine sedimentation) was used for the diagnosis of *S. haematobium* infection and this might have underestimated true infection levels. In view of these limitations and to identify the mechanisms for transmission and maintenance of this disease in THD, an epidemiological survey was carried out among the different population groups, to assess the distribution, intensity as well as describe the risk factors associated with occurrence of UGS in the study area.

Materials And Methods

Study area

This study was carried out in the THD, located in Fako Division of the South West Region of Cameroon. The coordinates of THD ranged from altitude 18 m, latitude 9°32’2” N to 9°40’9” N to altitude 220 m, longitude 9°25’7” E to 9°55’7” E, with a total surface area of 4840 km^2. This Health District is not geographically isolated from the UGS focus in Munyenge, Bafia Health Area, Muyuka Health District (Fig. 1b). THD district is made up of 8 health areas (HAs) (Holforth, Kange, Likomba, Mutengene, Mondoni, Mudeka, Missellele and Tiko Town) (Fig. 1c) and inhabited by a heterogenous population of approximately 124,423 inhabitants (Annual Report of the South West Regional Delegation of Public Health, 2017). This area is characterized by the presence of a local seaport that allows for fishing, import as well as export of goods between neighbouring countries. The rich volcanic soil encourages farming activities and industrial agriculture. This Health District hosts the Cameroon Development Corporation (CDC) plantations where banana, rubber and oil palm are cultivated and exported.

Tiko Health District has a coastal equatorial climate with two distinct seasons: a rainy season, which lasts from March to October followed by a short dry season of four months (November to February). The mean annual rainfall is about 4,524 mm. The temperature is relatively uniform throughout the year, with daily temperatures ranging from 28 °C to 33 °C [24]. This temperature range favours the development rate of the parasite within snails and the infectivity of cercaria [26]. The main water courses in the Tiko municipality include River Mungo, the Ombe River, Ndongo and Benyo streams which empty into the sea. Most of the tributaries have been turned into refuse dumps, which lead to slow flow or stagnant water, and in turn makes them suitable breeding sites for snail intermediate host (Fig. 2a). Access to safe water is poor due to frequent non-flow of community and household water [24] and requirement for immediate payment of water fetched from private owned pipe-borne water sources (personal observation). Consequently, the local population makes frequent use of the streams for their daily household chores (Fig. 2b and c).

Study design and sampling technique

The study was a cross-sectional community-based design carried out between June to August 2018. Out of the eight health areas, five health areas were excluded from the study, Kange and Tiko town are open to the high sea, Mondoni, Missellele and Mudeka were the riskiest areas during the era of political unrest in the English-speaking part of the Country [25] (Fig. 1). Thus, three health areas out of the eight health areas within the THD were selected for this study namely, Likomba, Holforth and Mutengene. However, at the district level, the Holforth health area (the largest and most populated) is divided into Holforth and Holforth-Likomba areas. In principle, four HAs were considered for the survey; Likomba, Holforth, Holforth-Likomba and Mutengene. Information on the population size of each selected HA and number of communities (quarters) were sorted from the Regional Delegation of Public Health, SWR (Annual Report South West Regional Delegation of Public Health, 2017). Twelve communities were purposively selected considering the water contact points (Activity reports documented by public health registry in the district, 2017) (Fig. 1). The minimum sample size allocated per community was estimated from the total population size of the entire THD.

Sample size determination

The sample size for this study was determined based on the Yaro Yamane’s approach for finite population [27]. This was made possible by using the formula;

$n = N/ 1 + N (e)^2$

Where,

n = the expected sample size,

N = the finite population out of which the sample was drawn,

e = the level of significance (or limit of tolerable error).

For this work, the estimated population size (N) from the 2017 population statistics was 124500 (Regional Delegation of Public Health, SW Region, 2017), and the level of significance (e) was 0.05 or 5%.

So, estimated Sample Size = $124500/1 + 124500 (0.05)^2 = 11047/312.25 \approx 399$

The minimum estimated sample size calculated per health area was 399. This was multiplied by 3 (number of health areas included in the study) to give 1197.

Following administrative clearances and ethical approval for the study, informed consent/assent forms and information sheets, which highlighted the purpose, risks and benefits of the study, were given to potential participants. For children less than 13 years old, assent was gotten from their parents or legal guardians, while for those less than 18 years old, consent was obtained from both the parent and the child. Participants who were above 18 years gave their consent before enrolment into the study. Prior to the commencement of the study, community engagement in the selected communities were conducted with the support of the Health District, local chiefs, administrative and Community Health Workers (CHW). Participants were invited to the temporary data collection location in each community, and coordination was organized with the help of the CHW and leaders within the neighbourhood. The study team proceeded for sample collection upon obtaining consent/assent from the participants. A global positioning system (GPS) was used to get the accurate placement of the communities and water contact points.

Questionnaire survey

The participants were interviewed by a field researcher to record socio-demographic characteristics (age, gender, residence), socioeconomic status (educational level and occupation) and history of *S. haematobium* infection (visible haematuria). Information on whether the participant had been living in the health district or came from other areas was noted. Access to the different water sources for household use (communal or household pipe-borne water) was documented. Information was also collected on the distance to open water sources as well as water-related activities which include agricultural practices, fishing, swimming, bathing, washing, laundry and crossing the stream.

The degree of water contact was calculated by using the formula, Σ (R x F), as described by Lima *et al.* [28]; where R is the score for the reason for the contact and F the score for the frequency of contact. The reasons were given the following scores: 5 (for bathing, swimming, or playing in the streams), 4 (laundering or agricultural purpose), 3 (collecting water for the household, dish-washing or car/motor bike washing), and 2 (fishing or crossing the streams). The frequency of contacts was scored as 28 (daily or at least one contact a day), 4 (weekly or at least one contact a week), 2 (at least two contacts a month), and 1 (less than two a month). Totals of 2–99 were considered as degree I and ≥ 100 as degree II.

Parasitology

Sample collection and processing

Each consented participant received a sterile, dry, screw-top, transparent, pre-labelled urine bottle. Participants were instructed to collect 20 mL of mid-stream urine sample in the container between 10 am and 2 pm. Immediately, urine samples were tested for microhaematuria using urine reagent strips (URIT Medical Electronic Co., Ltd. P.R. China) following manufacturer's instructions. Microhaematuria was identified as a trace or positive reagent strip colour reaction (+, ++, +++). The urine samples were later placed in a cool box for transportation to the Malaria Research Laboratory, University of Buea, where, they were processed using the syringe filtration technique [29] by a team of trained laboratory technicians.

Briefly, each urine specimen was well mixed, and 10mls aliquot of urine sample was withdrawn into a syringe. Filter holder fitted with 25 mm millipore filter membrane (Sterlitech Polycarbonate (PCTE) membrane filters, USA) of pore size 8 μm was attached to the syringe. The urine sample was then filtered through the filter, membrane. Filter holder was removed from the syringe and disassembled to expose the filter paper. With the aid of a pair of blond forceps, each membrane was carefully removed and placed upside down onto a microscope slide. A drop of Lugol's iodine was added and slides were examined for *S. haematobium* eggs under the x10 objective of an Olympus NYUSA microscope. Microhaematuria is considered as proxy-diagnosis of UGS, an accepted marker in the rapid diagnosis of *S. haematobium* infection in urine [30]. Thus, an individual was considered positive for *S. haematobium* when he/she was diagnosed positive by microscopic examination and/or urine reagent strip. The number of eggs was counted and classified per 10 mL of urine as light (< 50 eggs/10 mL of urine) or heavy (≥ 50 eggs/10 mL of urine) as defined by the World Health Organization [31].

Data management and statistical analysis

All data were entered, validated, and analysed using SPSS Statistics version 20 (SPSS Inc., Chicago, IL). Proportion of *S. haematobium* was compared between different groups (health area, sex, age groups, level of education, occupation, source of water for household use and degree of contact) using Pearson Chi square test. Crude odds ratios were estimated and factors associated with infection to be included in the multivariate logistic regression model were identified. Variables that had a P value < 0.20 in bivariate analysis or biological plausibility were included in the multivariate logistic regression model. Using the enter method, variables which showed independent association with infection at a significance level of P < 0.05 were retained in the model. Mean egg load was compared between groups using non-parametric Mann-Whitney and Kruskal Wallis test. Relationship between presence and intensity of *S. haematobium* eggs with micro-haematuria and proteinuria was determined using Pearson Correlation. A p-value < 0.05 was considered significant.

Cartographic analysis

ArcGIS, Version 2.18 (Environmental Systems Research Institute, Inc., Redlands, Calif.) was used to evaluate the spatial distribution of UGS infection and behavioural risk factor (measured by degree of water contact). Types of improved water sources and distance to stream were mapped. Association between the distribution of UGS and explanatory variables were evaluated at community scale (community as geographic unit).

Results

Characteristics of study participants

A total of 1029 individuals (age range: 5–75 years) were enrolled from four health areas namely; Mutengene, Likomba, Holforth-Likomba and Holforth HAs. For drinking water, domestic and recreational purposes, people living in THD use both the stream and improved water sources (pipe-borne water, boreholes, or protected wells). Despite high access (84.5%) to improved water facilities, more than 50% of the population reported the use of stream water (Table 1). A considerable number of people rely on the stream for two or more water-related activities such as water collection, laundry, bathing, playing, swimming, fishing and farming. Compared with household pipe-borne water source, communal water supply is predominant (82.5%) in the area (Table 1), nevertheless, on most occasions, the water supply is irregular (personal observation).

Table 1
Characteristics of study participants

Variable	Characteristics	Number examined (n)	%
Health area	Likomba	234	22.7
	Holforth_Likomba	301	29.3
	Holforth	243	23.6
	Mutengene	251	24.4
Sex	Male	525	51.0
	Female	504	49.0
Age group (years)	5–14	543	52.8
	15–24	159	15.5
	25–34	123	12.0
	≥ 35	204	19.8
Level of education	At least secondary	469	45.6
	At least primary	560	54.4
Occupation	Housewife	59	5.7
	CDC worker	106	10.6
	Pupil/student	659	64.0
	Business/civil servant	121	11.8
	Farmer	84	8.2
Stream usage	Yes	563	54.7
	No	466	45.3
Activities in the stream	Water collection	46	4.5
	Washing	96	9.3
	Bathing	70	6.8
	Playing/Swimming	24	2.3
	Farming/Fishing	10	1.0
	Two or more activities	317	30.8

[¶] = communal/household pipe-borne water source, bore hold, protected well

Variable	Characteristics	Number examined (n)	%
	Reported no contact	466	45.3
Frequency to stream	Daily	284	50.4
	Weekly	245	43.5
	Monthly	34	6.1
Source of water	¶Improved water source/Stream	563	54.7
	Improved water source only	466	45.3
Pipe-borne water status	Communal water	717	82.5
	Household water	152	17.5
¶ = communal/household pipe-borne water source, bore hold, protected well			

Prevalence of S. haematobium **infection in the study area**

Schistosoma haematobium infection was not detected in the Mutengene HA. Thus, the overall prevalence of *S. haematobium* infection in the Likomba, Holforth-Likomba and Holforth HAs was 31.5% (245 /778) (95% CI: 28.3–34.8). The Holforth-Likomba HA had the highest prevalence at 38.9% and Holforth HA having the least prevalence (23.5%) (Fig. 4). Figure 5 shows the spatial distribution of the twelve communities sampled in the four HAs and the respective prevalence of *S. haematobium* infection ranging from 0–56.9%. Nine out of twelve communities were affected. The prevalence of infection varied significantly ($\chi2$ = 66.21; P < 0.001) among the affected communities (Additional file 1). According to the endemicity of the disease, UGS was hyperendemic (P ≥ 50%) in Holforth quarter 4 (HOL Q4) and Holforth-Likomba quarter 1,2,3 (HOL-LIK Q1,2,3) neighbourhoods, and mesoendemic (10% ≥ P < 50%) in five communities (Additional file 1). Prevalence of UGS had a significant positive linear relationship (r = 0.8, p = 0.01) with the intensity of contact with water body; as the degree of contact with water increases, the chances of its inhabitants having *S. haematobium* infection increased. The prevalence of UGS in relation to degree of water contact in each community is mapped in Figs. 5. The distance of respondents to stream was a determinant of infection with *S. haematobium* ($\chi2$ = 108.5; P < 0.001); where most of the individuals living in highly affected communities (HOL Q4 and HOL-LIK Q1,2,3) indicated residence in close proximity (< 100 m) to water bodies (Additional file 2). More improved water sources ($\chi2$ = 433.65; P < 0.001) were found in Likomba-Upper Costen/Middle Costen (LK-UC/MC), Likomba-Water tank (LK-WT), HOL Q2 and HOL Q6 identified as less affected communities (Additional file 3). Moreover, populations living in these neighbourhoods live far from surface water points and generally have low degree of contact with water (Figs. 5 and 6).

Table 2 summarises the univariate analysis of determinant factors of *S. haematobium* in the THD based on the surveyed sociodemographic and water contact behaviour. The infection was frequent among the age group 5–14 years, pupils/students and individuals who had attained at least secondary level of education. Also, a higher prevalence was observed among those, who made daily contact with stream, reported playing and swimming in the stream as well as make multiple water contact activities when compared with others in their respective categories. The difference was significant. The male participants had higher infection than female participants, though not statistically significant (Table 2).

Table 2
Univariate analysis of socio-demographic and water contact behaviour associated with urogenital schistosomiasis in the study population

Variable	Category	*S. haematobium* infection %(n)	P value [$]
Health area	Likomba	30.3(71)	0.001
	Holforth_Likomba	38.9(117)	
	Holforth	23.5(57)	
Sex	Male	32.9(138)	0.35
	Female	29.8(107)	
Age group (Years)	5–14	37.7(156)	< 0.001
	15–24	31.7(39)	
	25–34	25.8(24)	
	≥ 35	17.6(26)	
Level of education	Secondary	35.4(126)	0.03
	Primary	28.2(119)	
Occupation	Housewife	30.0(12)	
	CDC worker	18.5(17)	0.001
	Student/Pupil	36.5(184)	
	Business/Civil servant	26.3(21)	
	Farmer	17.7(11)	
Stream activity	Two/more activities	53.5(137)	< 0.001
	Water collection	33.3(14)	
	Washing	40.3(25)	
	Bathing	28.3(15)	
	Playing/swimming	53.8(7)	
	Farming/fishing	25.0(2)	
	No activity	13.1(45)	

¶ = Σ (R x F), where R is the score for the reason for the contact and F the score for the frequency of contact.

[$] = Values are from Pearson Chi square test

Variable	Category	*S. haematobium* infection %(n)	P value [$]
Stream frequency	Daily	62.4(159)	< 0.001
	Weekly	21.5(32)	
	Monthly	30.0(9)	
[¶]Degree of contact	Degree II (≥ 100)	64.2(145)	< 0.001
	Degree I (2–99)	26.4(55)	
[¶] = Σ (R x F), where R is the score for the reason for the contact and F the score for the frequency of contact.			
[$] = Values are from Pearson Chi square test			

Intensity of S. haematobium **egg excretion and associated clinical outcome**

The geometric mean (GM) egg count was 28.7 eggs per 10 mL of urine (range: 2–450), where the proportion of infected individuals with light infection was 61.4% (105) (< 50eggs/10 mL urine), while 38.6% (66) were heavily (≥ 50 eggs/10 mL of urine) infected. Egg load excretion was similar (χ^2 = 0.205; P = 0.65) in the different HAs (Table 3). Mean egg count decreased significantly (P = 0.02) with increased age, where the 5–14 years age group had the highest egg load excretion and the least egg counts were recorded among older individuals (25–34 and ≥ 35 years). In addition, intense contact with stream (degree II) was associated with higher egg load excretion than less contact with stream (degree I). The difference was highly significant (P < 0.001). Microhaematuria was strongly related to egg excretion where microhaematuria was common (χ^2 = 21.1; P < 0.001) among individuals who excreted eggs (70.3%) than in those with no infection (29.7%). Although more individuals with light infection (P < 0.001) showed no urothelial clinical symptoms (microhaematuria and proteinuria), the presence of these symptoms did not differ with intensity of egg excretion (Table 3).

Table 3
Intensity of *S. haematobium* infection in the study population stratified according to socio-demographic, water contact behaviour and clinical presentation

Factors	Intensity of infection		P value$	GM egg load/10 ml urine (SD)	Range/10 ml urine	P value
	Light % (n)	Heavy % (n)				
Health area						
Likomba	60.4(29)	39.6(19)	0.79	25.8(73.5)	2–317	0.55[b]
Holforth_Likomba	60.0(48)	40.0(32)		26.9(103.5)	2–450	
Holforth	65.9(29)	34.1(15)		36.4(58.3)	2–225	
Sex						
Male	59.3(67)	40.7(46)	0.38	29.5(87.7)	2–450	0.76[a]
Female	66.1(39)	33.9(20)		27.3(82.3)	2–400	
Age group (years)						
5–14	57.6(72)	42.4(53)	0.13	34.4(88.6)	2–450	0.02*[b]
15–24	69.0(20)	31.0(9)		22.2(87.3)	2–330	
25–34	90.9(10)	9.1(1)		10.2(16.7)	2–53	
≥ 35	57.1(4)	42.9(3)		16.8(78.7)	2–216	
Level of education						
Secondary	57.0(49)	43.0(37)	0.21	29.4(70.0)	2–317	0.65[a]
Primary	66.3(57)	33.7(29)		28.1(99.3)	2–450	
Occupation						
Housewife	80.0(4)	20.0(1)	0.34	25.8(19.6)	9–57	0.17[b]
CDC worker	81.8(9)	18.2(2)		11.6(62.4)	2–216	
Student/Pupil	59.4(85)	40.6(58)		31.9(87.7)	2–450	

$ = Values are from Pearson Chi square test

*= Statistically significant P value

[a] = Difference in egg load determined by Mann–Whitney U test

[b]= Difference in egg load determined by Kruskal–Wallis test

Factors	Intensity of infection		P value[$]	GM egg load/10 ml urine (SD)	Range/10 ml urine	P value
	Light % (n)	Heavy % (n)				
Business/Civil servant	75.0(6)	25.0(2)		17.8(112.9)	3–330	
Farmer	40.0(2)	60.0(3)		24.7(72.9)	2–183	
Stream activity						
Two/more activities	58.6(68)	41.4(48)	0.08	31.3(83.4)	2–400	0.04*[b]
Water collection	75.0(6)	25.0(2)		17.1(154.3)	2–450	
Washing	81.8(18)	18.2(4)		25.3(89.3)	5–330	
Bathing	53.3(8)	46.7(7)		31.7(70.1)	3–280	
Playing/swimming	33.3(2)	66.7(4)		55.4(79.7)	7–215	
Farming/fishing	0.0(0)	100.0(1)		54.0(0)	54–54	
No contact	100.0(4)	0.0(0)		2.9(0.8)	2–4	
Stream frequency						
Daily	55.2(80)	44.8(65)	0.001	33.8(90.6)	2–450	< 0.001*[b]
Weekly	94.1(16)	5.9(1)		15.6(12.1)	5–51	
Monthly	100.0(6)	0.0(0)		14.5(9.7)	7–34	
No contact	100.0(4)	0.0(0)		2.9(0.8)	2–4	
Degree of contact						
Degree II (≥ 100)	53.7(72)	46.3(62)	< 0.001	35.9(86.9)	2–400	< 0.001*[a]
Degree I (2–99)	88.2(30)	11.8(4)		15.5(77.3)	2–450	
Microhaematuria						

[$] = Values are from Pearson Chi square test

*= Statistically significant P value

[a] = Difference in egg load determined by Mann–Whitney U test

[b]= Difference in egg load determined by Kruskal–Wallis test

Factors	Intensity of infection		P value$	GM egg load/10 ml urine (SD)	Range/10 ml urine	P value
	Light % (n)	Heavy % (n)				
Yes	50.4(61)	49.6(60)	< 0.001	40.1(94.0)	2–450	< 0.001*[a]
No	88.2(45)	11.8(6)		13.0(42.1)	2–280	
Dysuria						
Yes	85.7(12)	14.3(2)	0.05	22.8(114.6)	2–450	0.47 [a]
No	59.5(94)	40.5(64)		29.3(83.3)	2–400	
Frequent urination						
Yes	37.5(3)	62.5(5)	0.15	22.8(114.6)	2–450	0.25[a]
No	62.8(103)	37.2(61)		29.3(83.3)	2–400	
Proteinuria						
Yes	48.3(43)	51.7(46)	< 0.001	41.2(102.2)	2–450	< 0.001*[a]
No	75.9(63)	24.1(20)		19.5(55.6)	2–280	
$ = Values are from Pearson Chi square test						
*= Statistically significant P value						
[a] = Difference in egg load determined by Mann–Whitney U test						
[b]= Difference in egg load determined by Kruskal–Wallis test						

Risk factors associated with *S. haematobium* infection in the THD

In Table 4, the binary logistic regression analysis presents determinant factors associated with the risk of *S. haematobium* infection based on sociodemographic factors and water contact behaviour in THD. The most important factors associated with infection in the study area were age, secondary level of education and degree of water contact. Individuals in the younger age group (5–14 years) were observed to be 3.6 times (95% CI: 1.1–12.0) more likely to be infected when compared with those of the older age groups. More so, individuals who had secondary level of education were twice (95% CI: 1.2–3.2) more likely to be infected with *S. haematobium* compared with those who had at most primary level of education. Participants who were classified as having high degree contact (degree II) with water had 5.2 times increased odds (95% CI: 3.4–8.1) of *S. haematobium* infection.

Table 4
Risk factors associated with *S. haematobium* infection in the THD

Factors	% (n) positive	Unadjusted OR (95% CI)	P value[$]	[#]Adjusted OR (95% CI)	P value
Health area					
Likomba	30.3(71)	1.4(0.95–2.13)	0.001	1.3(0.69–2.29)	0.44
Holforth_Likomba	38.9(117)	2.1(1.42–3.02)		1.2(0.74–2.13)	0.40
Holforth	23.5(57)	REF		REF	
Sex					
Male	32.9(138)	1.07(0.93–1.22)	0.35	1.2(0.8–1.93)	0.33
Female	29.8(107)	REF		REF	
Age group (years)					
5–14	37.7(156)	3.8(1.77–4.53)	< 0.001	3.7(1.1–12.2)	0.03
15–24	31.7(39)	2.18(1.23–3.84)		2.5(0.76–8.21)	0.13
25–34	25.8(24)	1.63(0.87–3.06)		2.6(0.91–7.27)	0.07
≥ 35	17.6(26)	REF		REF	
Level of education					
Secondary	35.4(126)	1.2(1.02–1.39)	0.03	2.0(1.23–3.23)	0.005
Primary	28.2(119)	REF		REF	
Occupation					
Housewife	30.0(12)	2.0(0.78–5.08)	0.001	1.2(0.25–6.24)	0.78
CDC worker	18.5(17)	1.0(0.45–2.43)		0.9(0.24–3.09)	0.83
Pupil/Student	36.5(184)	2.7(1.35–5.24)		1.0(0.30–3.68)	0.94
Business/Civil servant	26.2(21)	1.6(0.73–3.75)		2.5(0.73–8.39)	0.15
Farmer	17.7(11)	REF		REF	
Source of pipe-borne water					
Household pipe-borne water	34.7(195)	1.0(0.97–1.11)	0.32	NA	NA

[$]: Pearson Chi-square test; OR: odd ratio. [#]Adjusted OR using multivariate regression analysis.

Factors	% (n) positive	Unadjusted OR (95% CI)	P value$	#Adjusted OR (95% CI)	P value
Communal pipe-borne water	29.8(34)	REF			
Degree of water contact					
Degree II (≥ 100)	64.2(145)	2.0(1.72–2.55)	< 0.001	5.2(3.39–8.05)	< 0.001
Degree I (2–99)	26.4(55)	REF		REF	

$: Pearson Chi-square test; OR: odd ratio. #Adjusted OR using multivariate regression analysis.

Discussion

In the South West Region of Cameroon, reports on urogenital schistosomiasis are mostly from rural areas [7, 19–22]. Nevertheless, increased risk of schistosomiasis in peri-urban and urban towns is not uncommon. In 2018, an unmapped UGS transmission focus was observed in Tiko, a semi urban town in the THD in the Mount Cameroon area [23]. The current study reveals that UGS varied significantly among Has as well as communities. Proximity to stream, intense water contact and inaccessibility to improved water sources are important drivers of transmission of *S. haematobium* in the district.

Our study confirms that, there is *S. haematobium* transmission in three (Likomba, Holforth-Likomba and Holforth) out of the four health areas surveyed in the THD with the occurrence of infection at 31.5%. Overall, this prevalence places THD under the WHO classification of moderate risk communities [10]. Comparatively, lower prevalence rates have been observed in some urban and semi-urban settings in other Regions of Cameroon: 1.7% in Kékem [32] and 22.9% in Maroua [33]. These areas are targeted regularly for control of schistosomiasis and geohelminths and may account for the lower prevalence of schistosomiasis in these areas [32]. The occurrence of *S. haematobium* in THD may due partly to the presence and use of many fresh waterbodies (Moungo River) and its tributaries including several streams (Ndongo), which intersperse the Mount Cameroon Area. Another factor may be because the streams are in proximity to residential areas, which suggests frequent contact with water through swimming, bathing, fishing, farming, and laundry. The Mutengene HA had zero prevalence. Infrequent contact with water bodies, probably due to the far distance to water body, may account for the absence of infection in this HA (Fig. 5). The influence of topography on *Schistosoma* parasite transmission has been emphasized [34]. Mutengene is located at a higher altitude (220 m above sea level) with a hilly topographic terrain characterized by fast flow of the “Ndongo” stream which slows as it flows across the Tiko and Limbe towns. Similarly, Adie *et al*. [35] in Nigeria reported absence of schistosomiasis in communities located at higher altitudes. Conversely, lower altitudes could have a significant impact on the *Schistosoma* snail vector distributions, which are likely to be more concentrated in areas where there is a slow water current [36]. This may explain the predominance of UGS in the Holforth and Likomba Health Areas located at a lower altitude (18–80 m asl).

Among the nine affected communities, five namely; LK-UC/MC; HOL-LKQ1,2,3; HOL-LKQ4,5,6; HOL-LKQ 8,9 and HOLQ6 had infection > 31% with HOL-LKQ 1,2,3 (52%) and HOL-LKQ4 (56.9%) observed as high-risk communities (> 50%). This may be because most people in these communities live very close to the stream (> 80%) and are involved in intense contact with surface water. On the other hand, communities like HOL Q2 (92%; 12.5%) and HOL Q6 (83%; 17%), where most of the people live far (≥ 100 m) from open water surface, have access to alternative improved water sources such as protected wells and boreholes had low prevalence of infection [37]. This study strongly demonstrates the local transmission of schistosomiasis which suggests focus attention in the control of this disease. The maps obtained provide information about areas where studies and control efforts need to be focused. Preventive chemotherapy with praziquantel should be immediately put in place to reduce morbidity and interrupt transmission. Nevertheless, a malacological study on the distribution of snail intermediate hosts is crucial to elucidate the epidemiology of infection in the Health Areas in the THD.

The prevalence of *S. haematobium* decreased with age where school-aged children (5–14 years) were associated with increased odds and intensity of *S. haematobium* infection. This agrees with trends established in surveys carried out in Cameroon [20, 38] and other parts of Africa [17, 39]. Children are the most infected group of people in endemic areas, thus contributing significantly to the potential contamination of the aquatic environment [40]. Individuals of this age group are predisposed to schistosome infections due to their active life; hence increased water contact activities with cercaria infested streams [17]. Age-acquired immunity to reinfection contributes to declining trend in infection prevalence with increasing age [41].

The education level of the inhabitants was also strongly associated with the transmission of *S. haematobium*. Contrary to findings by Wepnje *et al*. [42] in Munyenge, Mount Cameroon Area, secondary level of education increased the odds of infection when compared to primary level of education. There is no distinct reason why individuals with secondary education had higher prevalence of infection. However, from statistical analysis, it is reasonable to suggest that the active age group (11–24 years) may fall more into the secondary education category.

Afiukwa *et al.* [43] suggested that 11–20 age group is the most active age group frequently engaging in activities that bring them in contact with infested water bodies. The sex dependent pattern of schistosome infections is widely reported [40]. Conversely, the prevalence of infection in males and females was similar. It is likely that, socioeconomic conditions, and habits in the THD could modify sex-biased tendencies to participate in activities that predispose to infection with *S. haematobium* [17, 37]. Males and females equally participate in activities such as bathing, swimming, and washing in streams, which served as major predisposing factors. Similar observations were made in previous studies in Nigeria [44], Cote d'Ivoire [17] and Cameroon [7].

Despite the presence of improved water facilities in the Health Areas, about 50% of the population visit the stream daily and one-third of those who use the stream, engage in two or more water-related activities. In most countries where schistosomiasis is endemic, inadequate access to clean water sources is major concern [45]. Distance from home, limited number of communal piped-borne water sources and requirement for immediate payment of piped-borne water are leading causes for limited access to water [42, 46]. Natural water bodies, many of which are infested with snails and infective schistosome cercariae, are common sources for domestic water in most schistosomiasis endemic areas [47]. The flow of pipe-borne water in THD is inconsistent, consequently, open water bodies such as streams and springs are common sources of water for majority of the people in this District. Usually people become infected with schistosomes when they make contact with infested water and cercariae penetrate the skin. Schistosome eggs are then excreted in human faeces or urine and when they get into water bodies, miracidia which are released from the eggs in turn infect the snails, which release cercariae which penetrate human skin [48]. The high dependence of the population on natural water bodies avails each water contact activity a potential risk factor of *S. haematobium* infection [49]. Intense water contact activity and daily visitation to stream (degree II) was associated with increased risk and intensity of *S. haematobium* infection in THD. This confirms previous reports in other endemic foci in Cameroon [7, 42, 50] and elsewhere [51]. Water contact at any point in time is linked mostly to practices including domestic activities and bathing. Laundry, bathing, and recreational swimming are the activities that cause the most exposure to cercaria-infested water because these do involve the immersion of large body parts, for long periods [28].

Limitations

In this study, only four HAs were surveyed due to inaccessibility to the other HAs. Future studies to target the other communities are important and will provide a clearer picture of UGS in the entire district. Secondly, this study relied only on statistical methods to establish the transmission of *S. haematobium* infection and associated factors in THD. Malacological studies are crucial to confirm that the streams are infested with snails which harbour the infective larvae of the parasite.

Conclusion

THD is a moderate risk endemic focus for UGS with an overall prevalence of 31.5%. Transmission occurs in Likomba, Holforth-Likomba and Holforth HAs and was not observed in Mutengene HA. The infection level varied significantly among affected communities from meso- to hyperendemic (12–56.9%). Proximity to stream, intense contact with stream and access to more improved water sources determined infection status of the communities. Among the participants, determinant factors associated with risk of *S. haematobium* infection and higher egg load excretion were younger age (5–14 years) and high degree of contact with open water surface. A malacological study on snail intermediate host(s) distribution and infectivity is fundamental to elucidate the mechanisms of *S. haematobium* transmission in THD. Nevertheless, control measures to effectively control and eventually eliminate the infection in this area will entail mass drug administration of praziquantel to affected communities, provision of safe and adequate water supply, health education, and snail control.

Abbreviations

THD
Tiko Health Distriict
CHW
Community Health Worker
UN
United Nations
UGS
Urogenital schistosomiasis
SWR
South west region
WASH
Water, sanitation and hygiene

Declarations

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Availability of data and materials

All data sets on which the conclusions of the research rely are presented in the paper and its supplementary file. However, data is available from the corresponding author upon reasonable request.

Authors' contributions

AEG: Participated in the design of the study, performed the experiments, and made inputs in manuscript write-up. JKAK: Conceived and designed the study and wrote the manuscript. WGB: Performed the experiment and analyzed the data. VD: Performed the experiment. HKK: Supervised, reviewed, and provided inputs to the manuscript. All authors read and approved the final manuscript.

Ethics approval and consent to participate

Ethical clearance (2019/922-01/UB/SG/IRB/FHS) was obtained from the Faculty of Health Sciences Institutional Review Board the University of Buea, and administrative authorisation from the South West Regional Delegation of Public Health, Buea and District Medical Officer for Tiko Subdivision. Written and verbal informed consent was obtained before enrolment into the study. All participants positive for UGS were freely treated with praziquantel tablets (40 mg/kg of body weight) in collaboration with the local health authorities. Each participant was free to withdraw consent at any time. Identification codes were assigned to each study participant and limited access to study data was maintained to ensure confidentiality.

Competing interests

The authors declare that they have no competing interests.

Consent for publication

Not applicable

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Figures

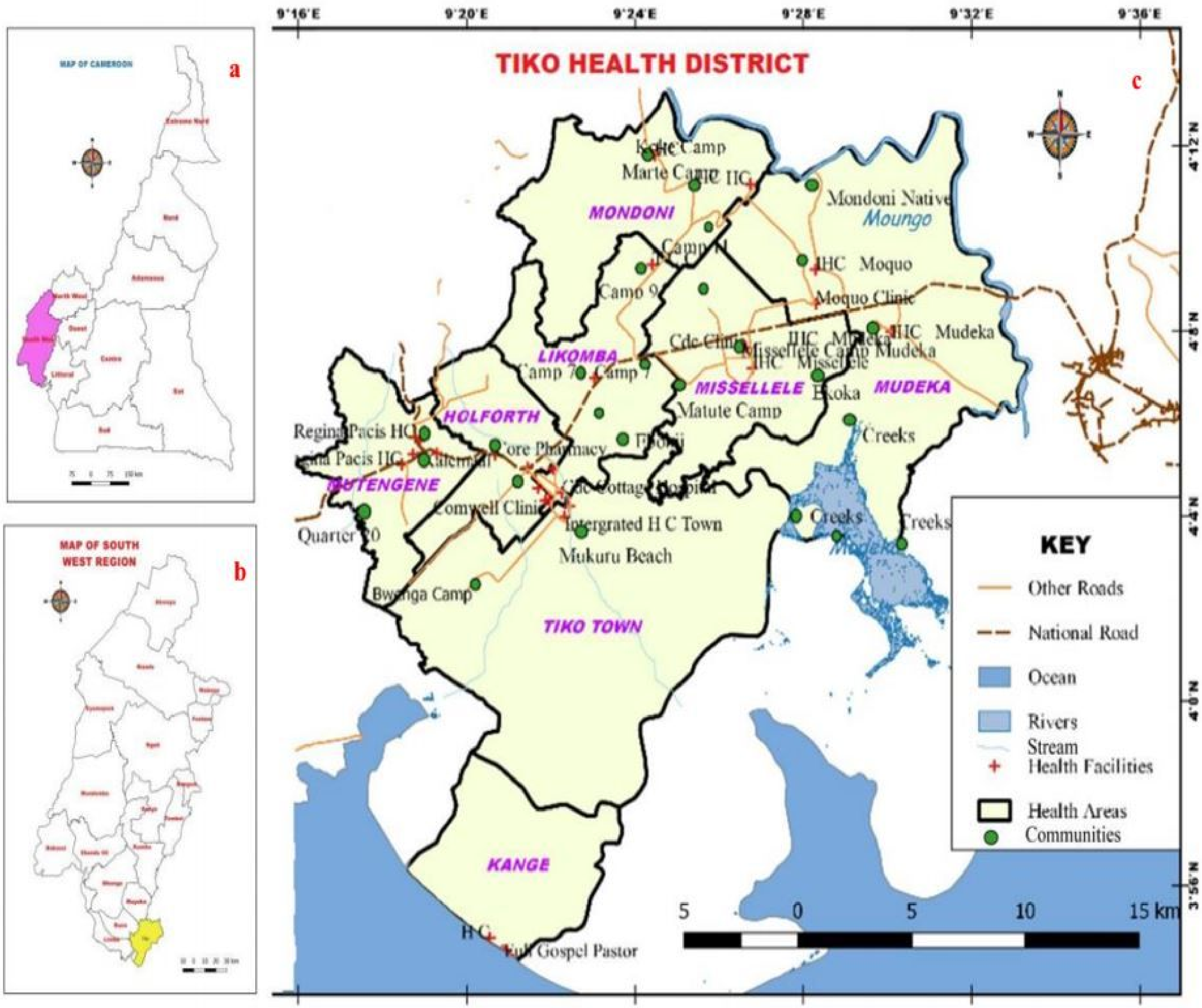

Figure 1

a: Map of Cameroon showing the location of South West Region, b: Map of South West Region, c: Map of Tiko Health District

Figure 2

a: Snail infested stream, b & c: Some stream contact activities

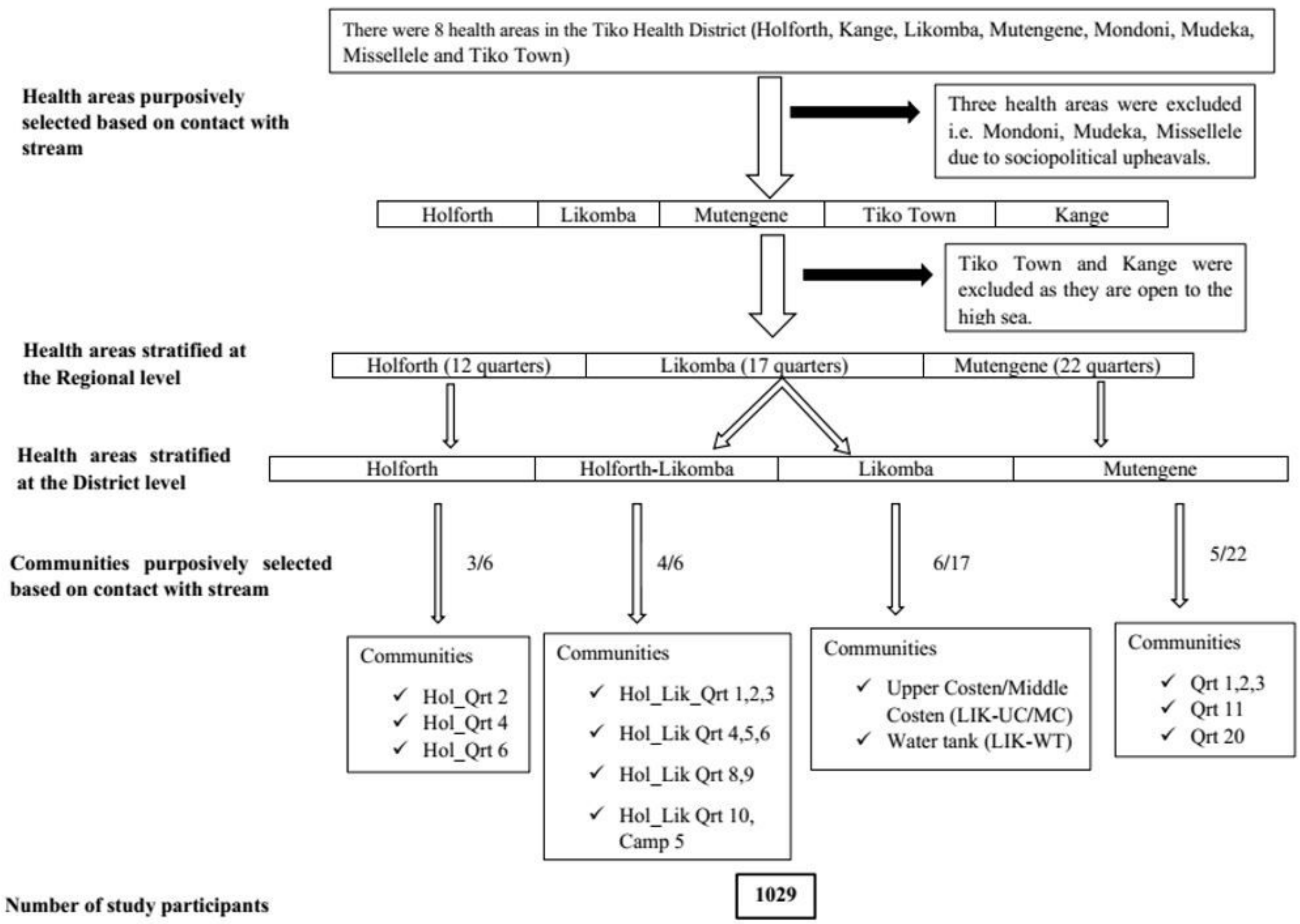

Figure 3

Flow diagram showing selection of study communities

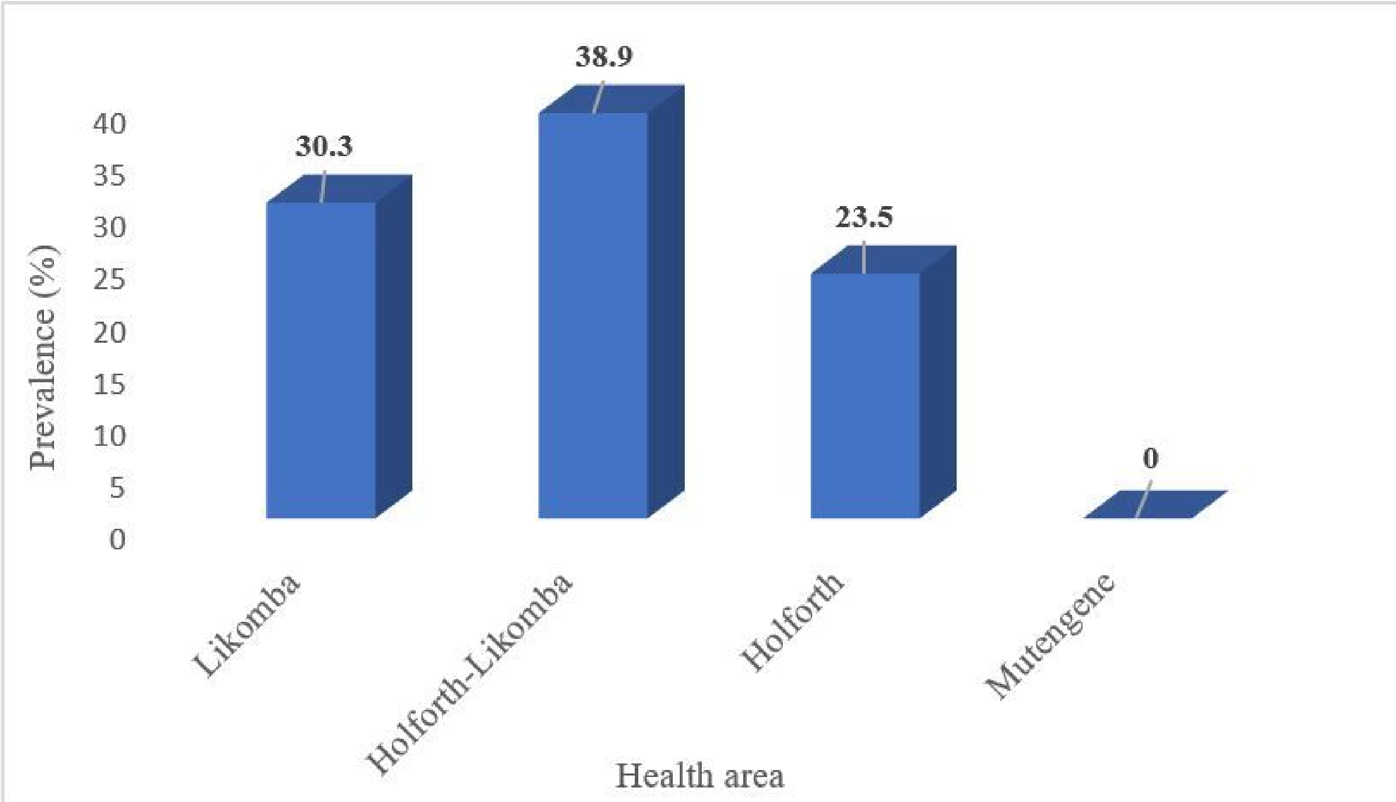

Figure 4

Prevalence of S. haematobium infection within the four infected health areas

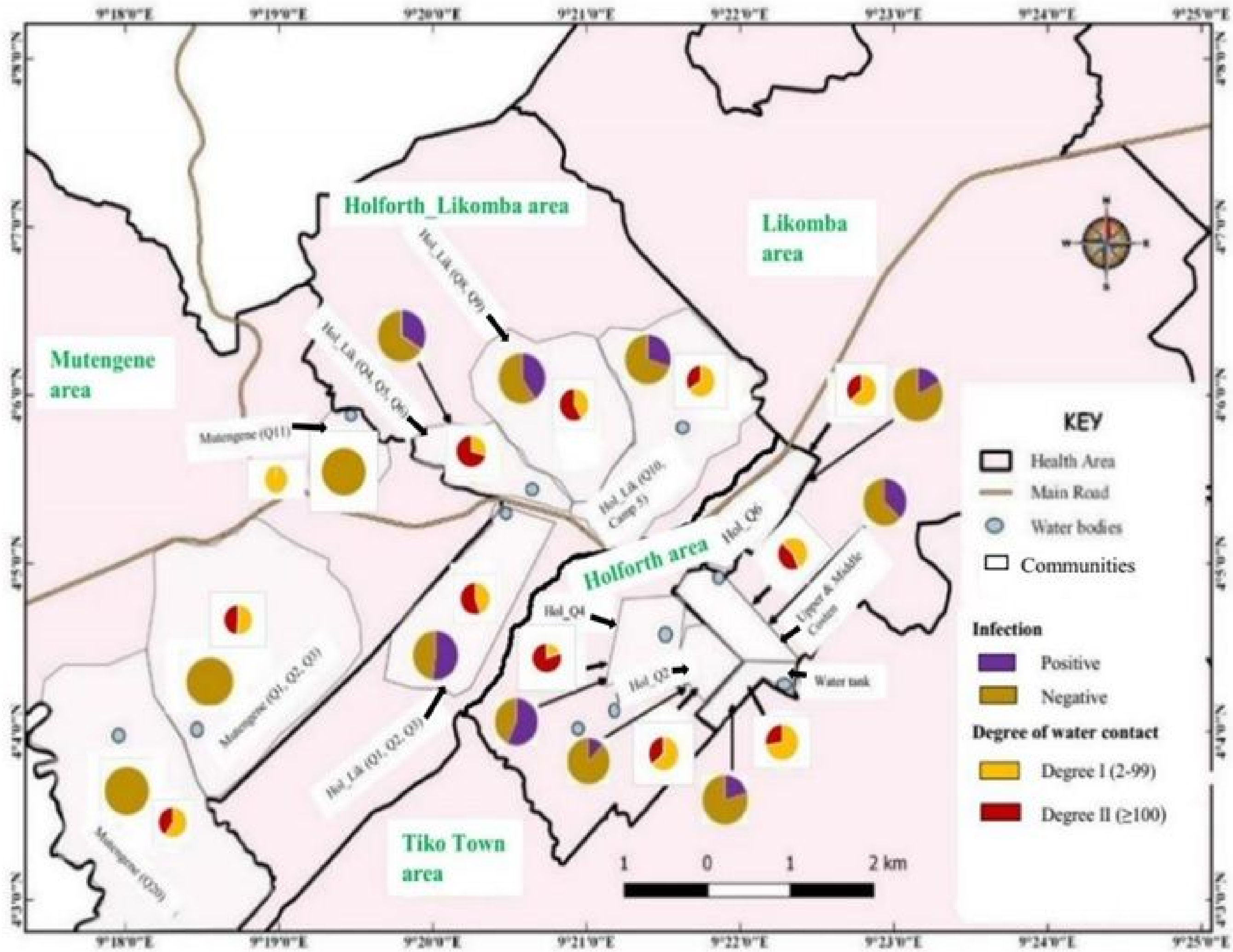

Figure 5

Prevalence of S. haematobium infection and degree of contact within different communities of the THD

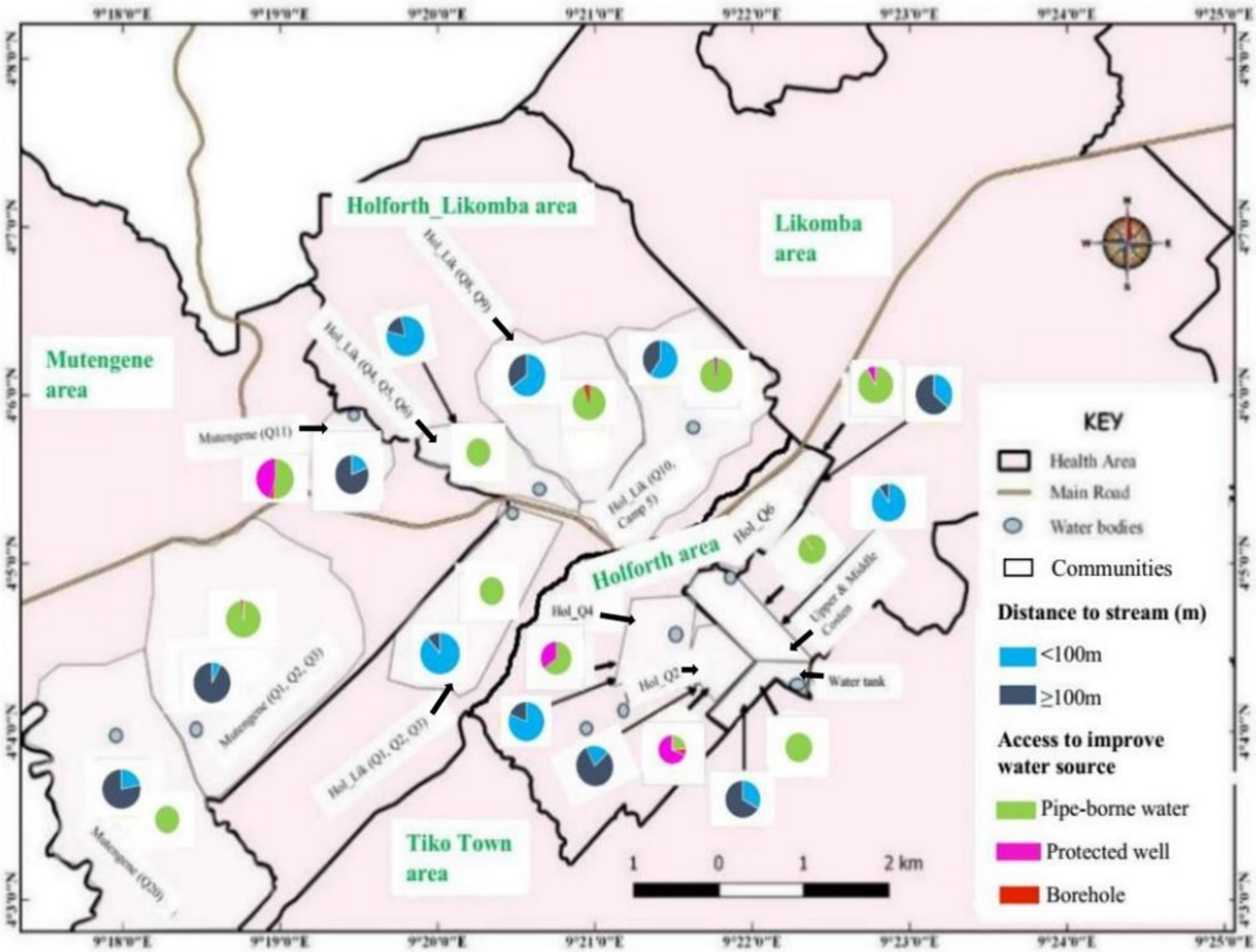

Figure 6

Distribution of proximity to stream and access to improved water source within different communities of the THD

Supplementary Files

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