HOSTED BY
ELSEVIER
Contents lists available at ScienceDirect
Asian Pacific Journal of Tropical Biomedicine
journal homepage: www.elsevier.com/locate/apjtb

Original article http://dx.doi.org/10.1016/j.apjtb.2016.04.003

Cross-sectional study and spatial distribution of schistosomiasis among children in Northeastern Nigeria

Robert Soumay Houmsou[1*], Sam Mao Panda[2], Sambo Obadiah Elkanah[1], Liatu Columbus Garba[1], Binga Emmanuel Wama[1], Elizabeth Une Amuta[3], Santaya Larit Kela[4]

[1]*Department of Biological Sciences, Taraba State University, Jalingo, P.M.B 1167 Jalingo, Nigeria*

[2]*Biological Sciences Programme, Abubakar Tafawa Balewa University, Bauchi, P.M.B 0248 Bauchi State, Nigeria*

[3]*Department of Biological Sciences, University of Agriculture, Makurdi, P.M.B 2373, Makurdi, Benue State, Nigeria*

[4]*Department of Biological Sciences, Federal University Kashere, Kashere, Gombe State, Nigeria*

ARTICLE INFO

Article history:
Received 16 Dec 2015
Received in revised form 28 Dec 2015, 2nd revised form 13 Jan 2016
Accepted 20 Feb 2016
Available online 20 Apr 2016

Keywords:
Spatial
Schistosomiasis
Gashaka
Taraba State
Nigeria

ABSTRACT

Objective: To determine schistosomiasis level and risk factors that exposed school-aged children to infection as well as to model schistosomiasis map in relation to altitude and rainfall in Gashaka Local Government Area, Taraba State, Nigeria.

Methods: The study was conducted between January 2014 and June 2014. Urine and faecal samples were collected from 1 080 school-aged children and processed using the filtration and formol–ether concentration techniques, respectively.

Results: Irrespective of the schistosomes species, a point prevalence of 10.18% was reported out of the 1 080 children examined. Males were significantly infected than their female counterparts (11.75% *vs.* 8.43%) ($\chi^2 = 4.86$; $P = 0.027$), as well as children aged 6–10 (11.65%, 72/618) and 11–15 years (10.29%, 35/340) than the other age groups ($\chi^2 = 9.274$; $P = 0.026$). No significant difference was observed in schistosomiasis between children whose parents were educated (11.11%, 57/513) and not educated (9.88%, 53/536) ($\chi^2 = 1.342$; $P = 0.247$) and those whose parents are farmers (9.74%, 53/544) and non-farmers (10.63%, 57/536) ($\chi^2 = 0.787$; $P = 0.375$). Proximity to water bodies (distance < 500 m) (odds ratio = 1.809, confidence interval = 1.057–3.094; $P = 0.003$ 1) and fishing (odds ratio = 2.632, confidence interval = 1.397–4.958; $P = 0.003$) were the risk factors exposing children to infection. The spatial distribution pattern of schistosomiasis showed that the infection was significantly higher in Serti A (22.2%, 26/180) and Mayo-Selbe (21.1%, 38/180) than the other localities ($\chi^2 = 92.99$; $P = 0.000$).

Conclusions: This study reported a moderate level of infection among school-aged children with proximity to water bodies and fishing as the main risk factors. The spatial distribution of schistosomiasis in the area will guide in efficient and effective control programmes at local level. It is recommended that continued efforts be made to scale-up distribution of praziquantel to high risk areas so as to curb the progression of the disease.

1. Introduction

Schistosomiasis caused by *Schistosoma mansoni* (*S. mansoni*) and *Schistosoma haematobium* (*S. haematobium*) continues to remain a public health problem in many parts of developing countries most especially sub-Saharan Africa where there is inadequate supply of clean drinking water. This constrains inhabitants to rely on cercariae infested ponds, streams,

*Corresponding author: Robert Soumay Houmsou, Department of Biological Sciences, Taraba State University, Jalingo, P.M.B 1167 Jalingo, Nigeria.
Tel: +234 8032982979
E-mail: rs.houmsou@gmail.com

The study protocol was performed according to the Helsinki declaration and approved by the Directorate of Health, Gashaka Local Government Area, Taraba State. Informed written consent was obtained from parents.

Foundation Project: Supported by the Tertiary Education Fund (Tetfund), Nigeria under Grant No: TETFUND/TSU/14/017.
Peer review under responsibility of Hainan Medical University. The journal implements double-blind peer review practiced by specially invited international editorial board members.

rivers and water from irrigation canals purposed for agriculture. It is estimated that 249 million people are infected worldwide with schistosomiasis among which an estimated 231 million live in sub-Saharan Africa [1]. In most endemic areas, the disease has been linked to epidemiological, socio-economic and environmental factors [2–4].

In recent years, geographic information systems and remote sensing have been used to spatially determine distribution patterns and predictive maps model of schistosomiasis with environmental factors so as to guide and ensure effectiveness of control programmes. In sub-Saharan Africa, the use of such technological innovations in the control and prediction of schistosomiasis is poorly utilized and limited to only few studies: Cameroon [5], Kenya [6–8], Nigeria [9,10] and Tanzania [11].

Nigeria like most of the countries in sub-Saharan Africa has not achieved the Millennium Development Goals for access to safe drinking water and reduction by half of infections due to neglected tropical diseases. The number of people treated with preventive chemotherapy (praziquantel) was estimated at only 5.4% out of the 60.6 million requiring the chemotherapy [12]. Taraba State is one of such states in North East Nigeria where little has been done to improve access to safe drinking water and healthcare services to rural dwellers. Gashaka is one of such Local Government Areas (LGAs) where little progress has been made within the concept of the Millennium Development Goals to reduce schistosomiasis and soil-transmitted helminths among school-aged children. Majority of the inhabitants in the area depend on ponds, streams and rivers for drinking water and daily chores activities. Effective control interventions in the area only started within the past five years when there was a need to scale-up the distribution of praziquantel and albendazole to school children. These interventions were always done haphazardly with no prior epidemiological studies that would have guided efficient control programmes in the area. Previous studies extensively used published schistosomiasis studies and remotely sensed environmental data to model and predict infection for control purposes; this might consequently over or underestimate the real infection level of the disease in some areas which might subsequently affect control programmes. We attempted in this study to merge our understanding of both parasitological cross-sectional study and remotely sensed environmental data such as rainfall and altitude derived from satellite datasets to create an instrumental map that will help in guiding schistosomiasis control programme in Gashaka LGA, Taraba State, Nigeria where part of the Nigerian largest national park, the Gashaka Gumti National Park is located. Therefore, this study was conducted to determine schistosomiasis level in relation to some epidemiological factors among school-aged children and risk factors that exposed them to infection, as well as to model schistosomiasis maps in relation to environmental factors such as altitude and rainfall.

2. Materials and methods

2.1. Study area

Gashaka LGA is situated in the southeast of Taraba State and extends to approximately between 11°00′–12°00′ E and 07°30′–08°00′ N. The Local Government is bordered to the north and east by Adamawa State, to the southeast by the Republic of Cameroon, to the south by Sardauna LGA and to the west by Kurmi and Bali LGAs. The area lies within the typical Guinea savannah of Nigeria with a mountainous terrain and varying weather conditions ranging from dry-humid to tropical moist-humid in the lowlands, to sub-temperate climate on the highlands. The dry season starts from November to April and the rainy season from April to November. The area is mainly inhabited by civil servants, petty traders and military in the local government headquarters, Serti. Inhabitants living in the rural areas are mainly peasant farmers, fishermen and hunters who depend mostly on subsistence agriculture.

2.2. Study design, sample size determination and sampling procedures

This study was cross-sectional in design and conducted between January 2014 and June 2014. Prior to the commencement of the study, ethical approval and permission were obtained from the Directorate of Health, Gashaka LGA, Taraba State. Headmasters of the selected primary schools were duly informed by the Directorate of Health about the study. Written informed consent was obtained from parents and enrolled children were briefed on the significance of the study before sample collection. Equal number of samples was drawn from all the six localities, namely, Gashaka, Garbabi, Kwagin, Mayo-Selbe, Serti A and Serti B. The population size in each school was calculated using the following formula at 5% precision.

$$N = \frac{p\ (1-p)\left(Z_{1-\alpha/2}\right)^2}{d^2}$$

with p = 85% as the estimated prevalence in the area, $Z_{1\text{-}\alpha/2}$ = 1.96, d^2 = 0.002 5.

The calculated population size N was approximately 196 which was rounded-up to 200 to avoid bias in the selection of the pupils. A systematic random sample was then conducted to enroll 180 pupils with 10 as sample interval from the available 200 school children population in each school. In all, 1 080 pupils were enrolled for the study from the six localities.

2.3. Questionnaire administration

A structured questionnaire was given to each enrolled pupil to collect information on some epidemiological factors such as age, sex, level of education and occupation of parents, as well as risk factors for schistosomiasis such as water contact activities and distance from water sources. We only considered paternal factor for children that have both parents and maternal factor for those that are under maternal care.

2.4. Samples collection and laboratory procedures

Both 20 mL of urine and 2 g of stool samples were collected from each child using labeled universal bottles. The urine samples were collected between 10:00 h and 14:00 h during the day each child brought his/her early morning stool for examination. All specimens were analyzed within the premises of the school. Urine samples were analyzed by the standard filtration technique using 10 mL syringe, swinnex polypropylene filter holder (13 mm diameter) and polycarbonate membrane filters (12 μm porosity) (Sterlitech Corporation, Kent, USA), while stool samples were processed using the formol–ether concentration technique [13]. Microscopic examinations were done by two independent experienced laboratory technologists. A third one who was blind to the first two examinations randomly selected few positive slides for confirmation of the presence of parasites. All examinations were done under 10× and 40× objective lenses of an Olympus microscope. No child was reported having both *S. mansoni* and *S. haematobium* infections.

2.5. Acquisition of elevation and mean annual rainfall data

The environmental characteristics of the localities such as altitude and mean annual rainfall were extracted from the digital elevation datum of the United States Geological Survey (2014) and WorldClim (1950–2000) databases with spatial resolution of 10 m × 10 m and 1 km × 1 km, respectively.

2.6. Geographic information systems and image processing

All schools' geographic locations were collected using a GPS 12 (Garmin, Olathe, KS, USA), stored and processed using ArcGIS 9.3 software (Environmental Systems Research Institute, CA, USA) to produce the schistosomiasis spatial distribution maps. The data were geo-referenced in geographic (plane) projection using the Universal Transverse Mercator zone 32 North, datum WGS84. Three downloaded digital elevation images corresponding to the six localities were mosaicked using the Earth Resources Data Analysis System Imagine 9.1 software (ERDAS Inc. Atlanta, GA, USA) to give a single image that incorporates the six localities. Schistosomiasis spatial distribution maps related to altitude and rainfall were produced by overlaying the map of the schistosomiasis spatial distribution on each of the altitude and mean rainfall maps, respectively.

2.7. Statistical analysis

Data were entered in Microsoft Excel 2010 and exported into SPSS version 19.0 for analysis. *Chi*-square (χ^2) test was used to compare schistosomiasis level between location, age, sex, level of education and occupation of parents. The logistic regression model was used to test possible relationship between spatial distribution of schistosomiasis and environmental variables such as altitude and mean annual rainfall as well as to determine risk factors for schistosomiasis among school-aged children.

3. Results

3.1. Pattern of schistosomiasis among school-aged children in relation to epidemiological factors

Table 1 describes the pattern of schistosomiasis among school-aged children in relation to epidemiological factors in Gashaka LGA, Taraba State, Nigeria. An infection level of 10.18% (110/1 080) was reported out of the 1 080 children examined, with *S. mansoni* having higher occurrence (7.40%, 80/1 080) than *S. haematobium* (2.77%, 30/1 080). Irrespective of the schistosomes species, males were more infected (11.75%, 67/570) than their female counterparts (8.43%, 43/510) ($\chi^2 = 4.86$; $P = 0.027$). Likewise children aged 6–10 (11.65%, 72/618) and 11–15 (10.29%, 35/340) were significantly infected than the other age groups ($\chi^2 = 9.274$; $P = 0.026$). No significant difference was observed in schistosomiasis level between children whose parents were educated (11.11%, 57/513) and not educated (9.88%, 53/536) ($\chi^2 = 1.342$; $P = 0.247$) and those whose parents are farmers (9.74%, 53/544) and non-farmers (10.63%, 57/536) ($\chi^2 = 0.787$; $P = 0.375$).

3.2. Spatial distribution of schistosomiasis in Gashaka LGA

Figures 1 and 2 show the spatial distribution pattern of *S. mansoni* and *S. haematobium* respectively in Gashaka LGA, Taraba State, Nigeria. *S. mansoni* infection was reported in localities such as Mayo-Selbe (14.4%, 26/180), Serti A (22.2%, 40/180) and Serti B (7.8%, 14/180) ($\chi^2 = 113.83$; $P = 0.000$), while *S. haematobium* infection was reported in Mayo-Selbe (6.7%, 12/180), Garbabi (5.6%, 10/180), Serti B (3.3%, 6/180) and Gashaka (1.1%, 2/180) ($\chi^2 = 27.56$; $P = 0.000$). Irrespective of the schistosomes species, schistosomiasis was significantly higher in Serti A (22.2%, 26/180) and Mayo-Selbe (21.1%, 38/180) than the other localities ($\chi^2 = 92.99$; $P = 0.000$) (Figure 3).

3.3. Relationship between schistosomiasis and environmental factors (altitude and rainfall) and risk factors exposing children to infection in Gashaka Local Government

The logistic regression model showed that low altitude (< 716 m) was significantly associated [odds ratio (OR) = 2.133, confidence interval (*CI*) = 1.640–2.775; $P = 0.000$] with the distribution of schistosomiasis in the area (Figure 4), while no association was observed with mean annual rainfall (Figure 5). The estimated coefficients (intercept), the standard errors and the goodness of fit of the binary models were shown in Table 2.

Table 1

Schistosomiasis in relation to some epidemiological factors among school-aged children in Gashaka LGA, Taraba State, Nigeria. *n* (%).

Parameters		Schistosomiasis			
		No. examined	*S. haematobium*	*S. mansoni*	Both
Infection level		1 080	30 (2.77)	80 (7.40)	110 (10.18)
Sex	Male	570	27 (4.73)	40 (7.01)	67 (11.75)
	Female	510	3 (0.58)	40 (7.84)	43 (8.43)
Age (years)	1–5	108	2 (1.85)	1 (0.92)	3 (2.77)
	6–10	618	20 (3.23)	52 (8.41)	72 (11.65)
	11–15	340	8 (2.35)	27 (7.94)	35 (10.29)
	> 15	14	0 (0.00)	0 (0.00)	0 (0.00)
Education of parents	Educated	513	17 (3.31)	40 (7.79)	57 (11.11)
	Not-educated	536	13 (2.42)	40 (7.46)	53 (9.88)
Occupation of parents	Farmers	544	14 (2.57)	39 (7.16)	53 (9.74)
	Non-farmers	536	16 (2.98)	41 (7.64)	57 (10.63)

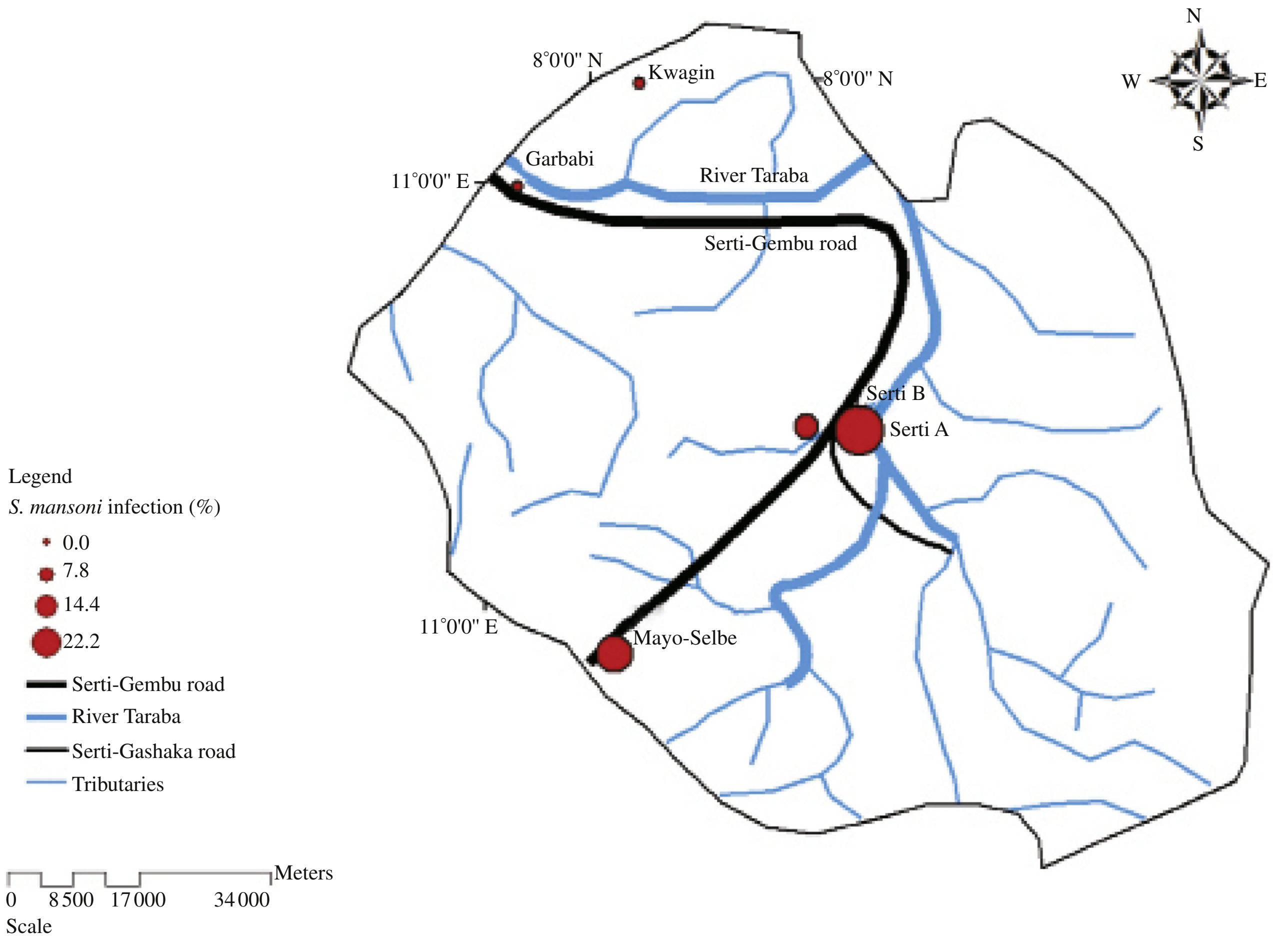

Figure 1. Spatial distribution pattern of *S. mansoni* in Gashaka LGA, Taraba State.

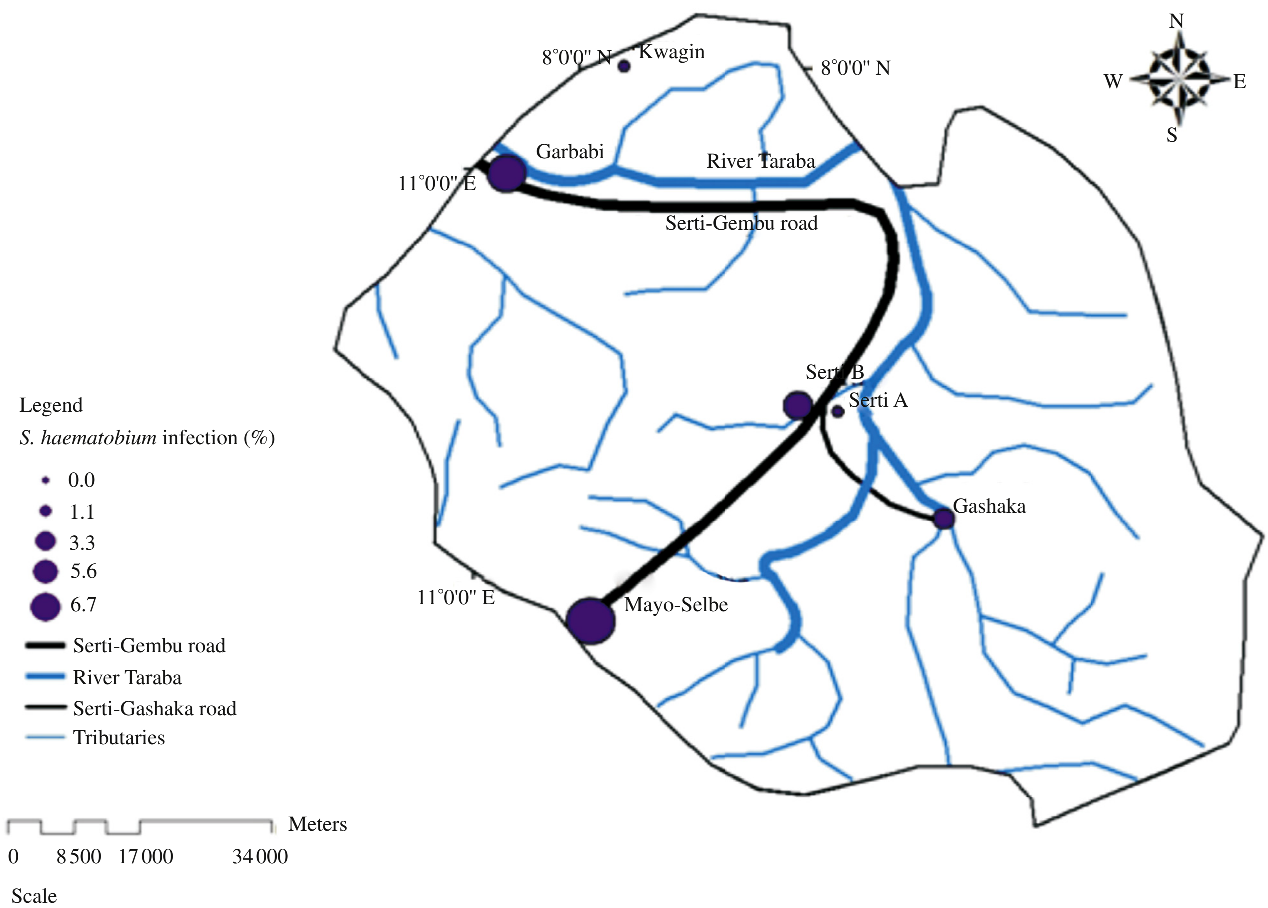

Figure 2. Spatial distribution pattern of *S. haematobium* in Gashaka LGA, Nigeria.

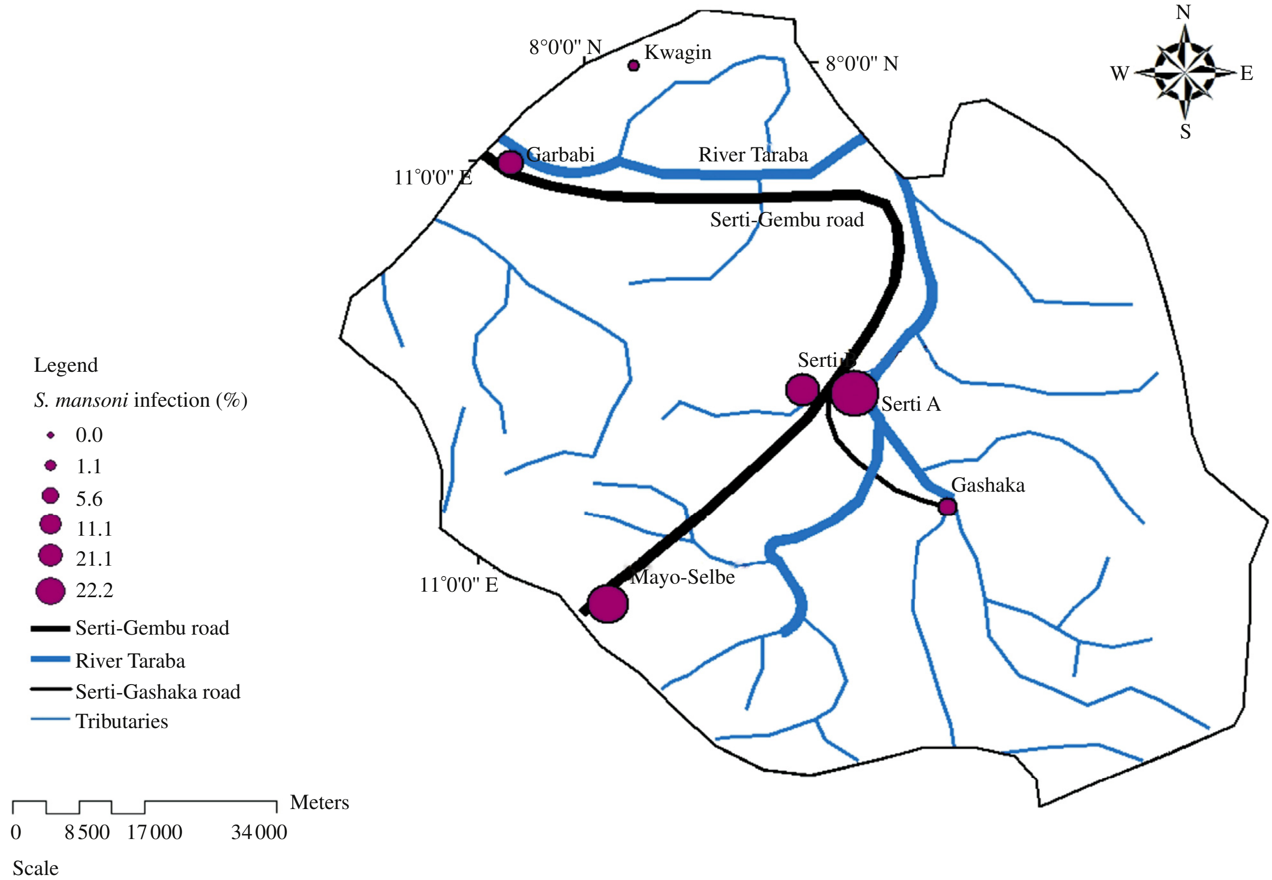

Figure 3. Spatial distribution of overall schistosomiasis in Gashaka LGA, Nigeria.

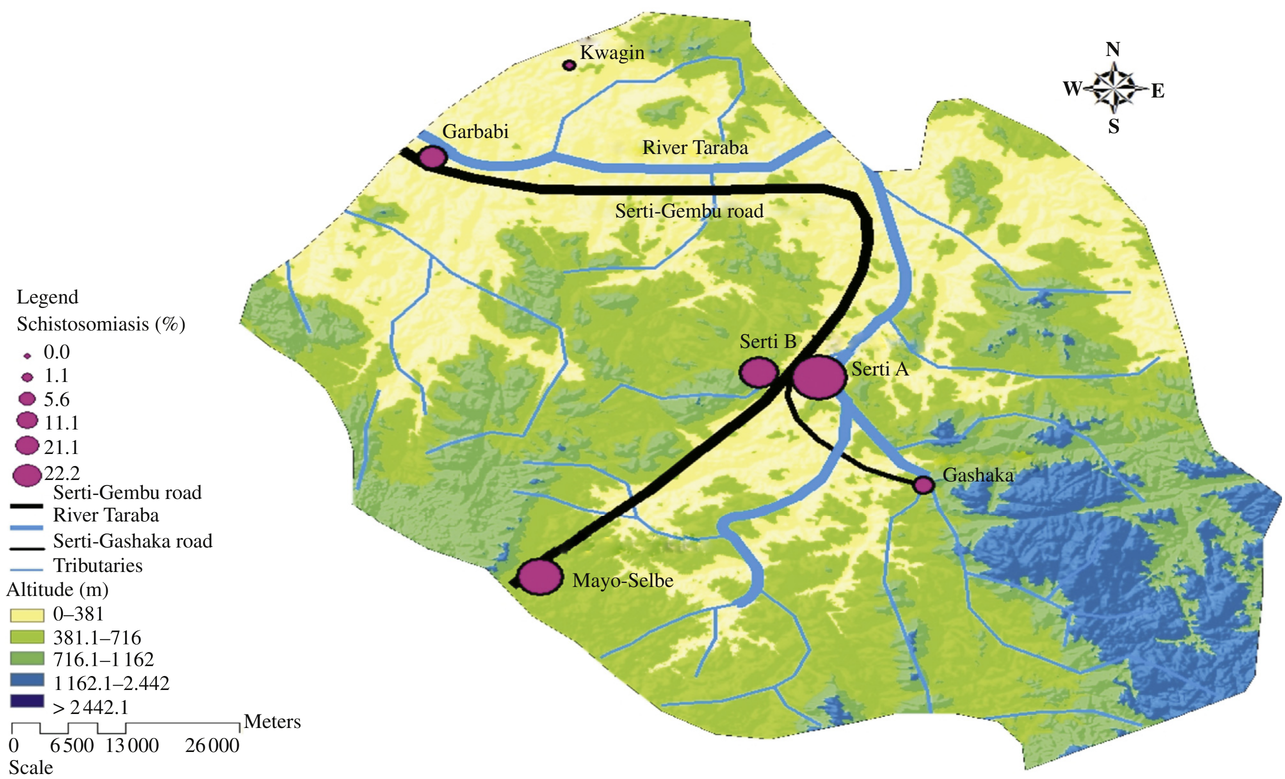

Figure 4. Spatial distribution of overall schistosomiasis in relation to altitude in Gashaka LGA, Nigeria.

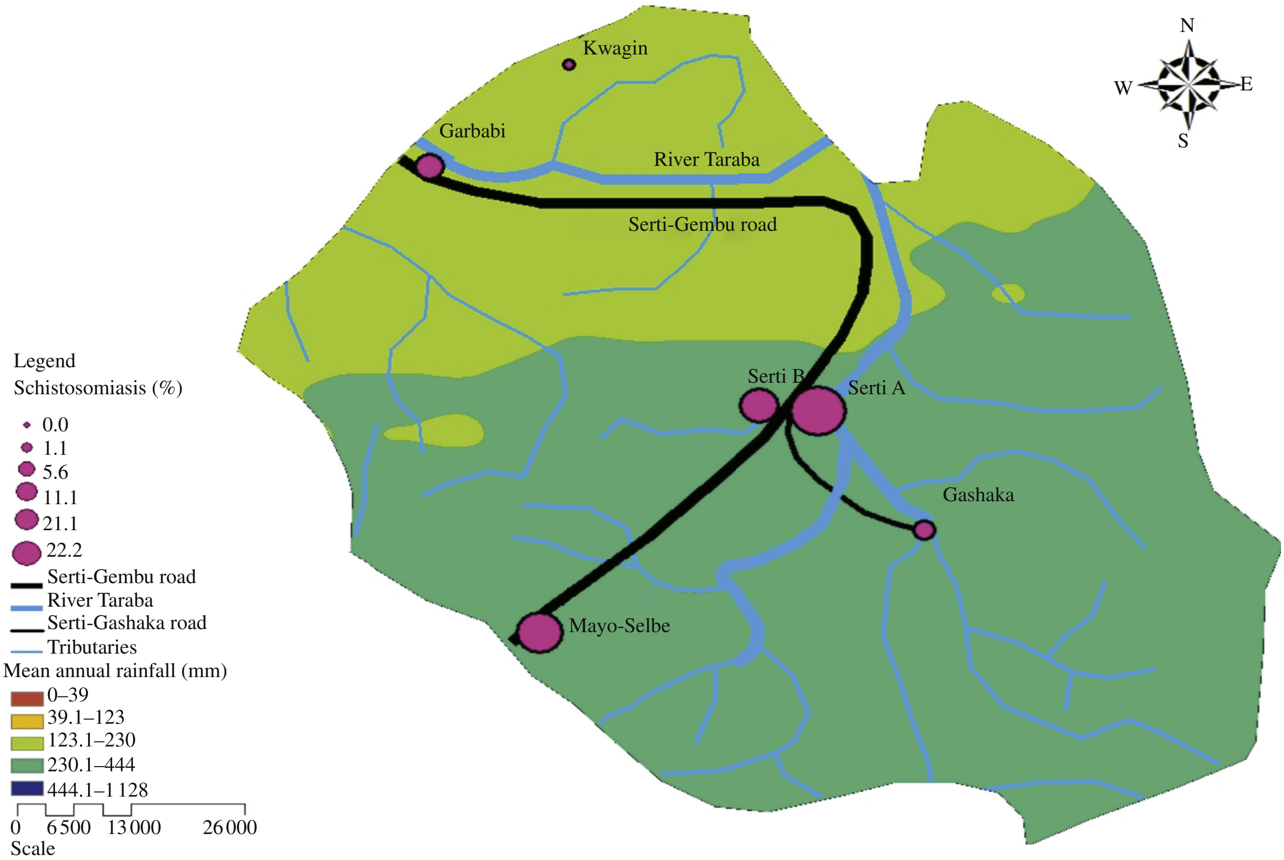

Figure 5. Spatial distribution of overall schistosomiasis in relation to mean annual rainfall in Gashaka LGA, Nigeria.

Table 2

Coefficients and goodness of fit of the logistic binary regression model predicting the positivity and negativity of schistosomiasis in schools surveyed in Gashaka LGA based on observed data of disease and environmental variables.

Variables		B	SE	Wald	*df*	*P*	OR	95% *CI* for OR	
								Lower	Upper
Model 1	Altitude	0.758	0.134	31.901	1	0.000	2.133	1.640	2.775
	Constant	−4.380	0.430	103.542	1	0.000	0.013	–	–
Model 2	Rainfall	−1.731	0.338	26.170	1	0.000	0.177	0.091	0.344
	Constant	−0.094	0.386	0.059	1	0.808	0.911	–	–

B: Regression coefficient; *df*: Degree of freedom; SE: Standard error. Variables remain in the equation.

Using logistic regression after forward stepwise (likelihood ratio) method, the model predicted all the 110 school children having schistosomiasis with an overall accuracy of 89.9%. The significant risk factors exposing children to schistosomiasis in Gashaka LGA were: proximity to water bodies (distance < 500 m) (OR = 1.809, *CI* = 1.057–3.094; *P* = 0.031) and fishing (OR = 2.632, *CI* = 1.397–4.958; *P* = 0.003). The estimated coefficients (intercept), standard errors and the goodness of fit of the binary models of all the factors are shown in Table 3.

Table 3

Logistic regression model predicting schistosomiasis in school children based on the various risk factors.

Variables	B	SE	Wald	*df*	*P*	OR	95% *CI* for OR	
							Lower	Upper
Distance	0.593	0.274	4.675	1	0.031	1.809	1.057	3.094
Swimming	−0.981	0.358	7.509	1	0.006	0.375	1.004	2.952
Fishing	0.968	0.323	8.972	1	0.003	2.632	1.397	4.958
Swimming and fishing	0.002	0.394	0.000	1	0.995	1.002	0.463	2.168

B: Regression coefficient; *df*: Degree of freedom; SE: Standard error.

4. Discussion

Schistosomiasis is among the most common neglected tropical diseases that affect school-aged children in sub-Saharan Africa with serious impact on their academic performance, nutritional status and normal growth [12]. The infection level reported in this study falls within the World Health Organization classification as moderate [14]. This moderate level of infection could be the result of the yearly administration of the preventive chemotherapy using praziquantel to children of various primary schools in the LGA during the past five years. Health and education officials in the area acknowledged the efforts made by the Nigeria government, World Health Organization, United Nations International Children's Emergency Fund and other non-governmental organizations that partnered and embarked on the large-scale deworming campaign programme in schools yearly so as to reduce the burden of the infection among school children in the area. Though published data were not found, local health and educational officials reported that schistosomiasis prevalence used to be highly endemic when control programmes were yet to start during the past five years.

From this present study, schistosomiasis still remains a serious public health problem among school-aged children though the overall prevalence (10.18%) is lower than 75.2% and 27.1% reported in communities near Zobe Dam Dutsin-Ma, Katsina State, Nigeria and Kassena-Nankana District of Northern Ghana, respectively [3,15]. Based on individual species, Shinkafi *et al.* [15] reported higher prevalence (72.0%) for urinary and lower prevalence (3.2%) for intestinal schistosomiasis than the present study; while Anto *et al.* [3] reported higher prevalence for both urinary (18.9%) and intestinal (10.9%) schistosomiasis than the present study. The prevalence of urinary schistosomiasis reported in the present study is comparatively lower than 15.5% reported in the neighboring Bali LGA [16]. Both *S. haematobium* and *S. mansoni* were found to be overlapping in Gashaka Local Government with some localities having both species (Serti B and Mayo-Selbe), others only having *S. haematobium* (Gashaka and Garbabi) and *S. mansoni* (Serti A). This overlapping was in part due to the presence of the snail vectors, the *Bulinus* and *Biomphalaria* species observed by our team in sources of water within and around the localities. The surprising fact is the distribution of these snails' species in Serti A and B localities. These two localities constitute the headquarters of the LGA, but both species of snails were observed in Serti B, while only *Biomphalaria* species was observed in Serti A. This could not be easily explained because our study did not take into consideration the distribution dynamics of the snails intermediate hosts in the localities surveyed. The higher infection level among school children in Mayo-Selbe and Serti than the other localities might be partly due to the irregular deworming campaign reported by inhabitants of the earlier locality and due to re-infection or drug resistance in the latter locality. The infection level in those areas needs to be monitored and addressed quickly so as to tackle the spread of the infection in the area. We observed that in the areas surveyed there is no provision of safe and potable water. Most inhabitants rely on snails infested ponds, streams and rivers for their daily chores activities. However, in Mayo-Selbe *S. mansoni* infection could be a cause for anthropozoonosis breakout in the area because the parasite was found infecting baboons which are non-human primates [17]. People in the area share water with such non-human primates as the locality is known as one of the enclaves of the Gashaka Gumti National Park. Proximity to water sources (< 500 m) and fishing were the two predisposing factors to schistosomiasis among the children examined. Several studies have reported high risk of infection among children living close to water bodies and those involved in water contact activities such as fishing and swimming [6,8,18,19]. Age and sex related prevalence of schistosomiasis showed female and children aged 1–5 years to be less infected than their counterparts. This could be due to their less involvement in water contact activities. Such observations have been reported in previous studies in Katsina and Rivers States of Nigeria [15,20], as well as other developing countries such as Ethiopia and Ghana [3,21]. Education and occupation of parents did not significantly affect distribution of schistosomiasis among children. This is because children in the area were observed to carry out same water contact activities irrespective of their parents' background. Such have been reported among children living in schistosomiasis and other neglected tropical diseases areas [2,22,23].

The relationship between low altitude and schistosomiasis in the area could be the result of water velocity from the versants of the highlands to the valley where it settles in ponds and other existing slow flowing streams that harbor the snail intermediate hosts. These sources of water remain throughout the year and become suitable for the breeding and survival of the snails. Inhabitants rely on those infested water ponds and streams for their daily chores thereby exposing themselves to infection. This observation has been reported in Ivorian children living at low altitude (< 400 m). These were found to be at 5-fold higher risk of schistosomiasis than those living on highlands [24]. Adie *et al.* [10] observed same among school children living at low altitude in Cross River State. The influence of altitude on schistosomiasis has been varying from one study to another. Ekpo *et al.* [9] observed no association between altitude and schistosomiasis in Ogun State, Nigeria.

Our study had several limitations: we did not carry out malacological surveys that would have investigated the population dynamics of the snail intermediate hosts. Secondly, we collected and examined only one urine and stool sample which would have given low sensitivity. Thirdly, the relatively small number of the localities surveyed in the LGA might have negatively affected the prediction accuracy. Lastly, our model did not include the land surface temperature, land cover and the normalized difference vegetation index which would have given a better prediction of schistosomiasis in the area.

In conclusion, the study revealed that schistosomiasis remained an important public health problem in the area though infection levels varied between children's localities. Low altitude, proximity to water bodies and fishing were found to be associated with presence of schistosomiasis among the children. It is therefore recommended that continued efforts for mass deworming campaign be maintained yearly so as to significantly reduce the level of infection among school-aged children. There is an urgent need to organize public health campaigns in Mayo-Selbe and Serti localities where deworming campaign has been poorly carried out and where there is great suspicion of re-infection, respectively. Provision of safe and clean water for domestic use should be made available by the government and other non-governmental organizations so as to curb transmission and re-infection in the area.

Conflict of interest statement

We declare that we have no conflict of interest.

Acknowledgments

This study was supported by the Tertiary Education Fund, Nigeria under Grant No: TETFUND/TSU/14/017. We remain grateful to the Vice-Chancellor of Taraba State University, Jalingo who granted approval to access the fund. The school children, teachers and head teachers of the various schools surveyed are greatly acknowledged for their cooperation. We remain indebted to the Directorate of Health, Gashaka LGA for all the necessary cooperation, support and logistics whenever we wanted their assistance. I thank my research assistants: Jerry Timothee Jerry, Ayetinum-Rimam Joseph and Ahijo for the help rendered during sample collection and examination.

References

[1] Schistosomiasis: number of people receiving preventing chemotherapy in 2012. *Wkly Epidemiol Rec* 2014; **89**: 21-8.

[2] Houmsou RS, Amuta EU, Sar TT. Profile of an epidemiological study of urinary schistosomiasis in two local government areas of Benue State, Nigeria. *Int J Med Biomed Res* 2012; **1**(1): 39-48.

[3] Anto F, Asoala V, Adjuik M, Anyorigiya T, Oduro A, Akazili J, et al. Childhood activities and schistosomiasis infection in the Kassena-Nankana district of Northern Ghana. *J Infect Dis Ther* 2014; **2**: 152.

[4] Worku L, Damte D, Endris M, Tesfa H, Aemero M. *Schistosoma mansoni* infection and associated determinant factors among school children in Sanja town, Northwest Ethiopia. *J Parasitol Res* 2014; **2014**: 792536.

[5] Brooker S, Hay SI, Tchuente LAT, Ratard R. Using NOAA-AVHRR data to model human helminths distributions in planning disease control in Cameroon, West Africa. *Photogramm Eng Remote Sens* 2002; **68**: 175-9.

[6] Woodhall DM, Wiegand RE, Wellman M, Matey E, Abudho B, Karanja DM, et al. Use of geospatial modeling to predict *Schistosoma mansoni* prevalence in Nyanza Province, Kenya. *PLoS One* 2013; **8**(8): e71635.

[7] Bisanzio D, Mutuku F, Bustinduy AL, Mungai PL, Muchiri EM, King CH, et al. Cross-sectional study of the burden of vector borne and soil-transmitted polyparasitism in rural communities of coast province, Kenya. *PLoS Negl Trop Dis* 2014; **8**(7): e2992.

[8] Nagi S, Chadeka EA, Sunahara T, Mutungi F, Justin YK, Kaneko S, et al. Risk factors and spatial distribution of *Schistosoma mansoni* infection among primary school children in Mbita District, Western Kenya. *PLoS Negl Trop Dis* 2014; **8**(7): e2991.

[9] Ekpo UF, Mafiana CF, Adeofun CO, Solarin AR, Idowu AB. Geographical information system and predictive risk maps of urinary schistosomiasis in Ogun State, Nigeria. *BMC Infect Dis* 2008; **8**: 74.

[10] Adie HA, Okon OE, Arong GA, Ekpo UF, Braide EI. Environmental factors and distribution of urinary schistosomiasis in Cross River State, Nigeria. *Int J Zool Res* 2014; **10**(2): 42-58.

[11] Brooker S, Hay SI, Issae W, Hall A, Kihamia CM, Lwambo NJ, et al. Predicting the distribution of urinary schistosomiasis in Tanzania using satellite sensor data. *Trop Med Int Health* 2001; **6**(12): 998-1007.

[12] World Health Organization. Investing to overcome the global impact of neglected tropical diseases: third WHO report on neglected tropical diseases. Genava: World Health Organization; 2015. [Online] Available from: http://who.int/neglected_diseases/9789241564861/en/ [Accessed on 25th November, 2015]

[13] Cheesbrough M. *Distric laboratory practice in tropical countries, part 1*. Cambridge: Cambridge University Press; 2009.

[14] World Health Organization. Helminth control in school-age children: a guide for managers of control programmes. Geneva: World Health Organization; 2011. [Online] Available from: http://apps.who.int/iris/bitstream/10665/44671/1/9789241548267_eng.pdf [Accessed on 25th November, 2015]

[15] Shinkafi BY, Adamu T, Abdullahi K, Mangas B, Bala Y. Schistosomiasis in communities around Zobe Dam Dutsinma, Katsina State, Nigeria. *Nig J Parasitol* 2012; **33**(1): 38.

[16] Monday IE, Francis JI, Lamidi BT, Mohammad SU. Investigating urinary schistosomiasis in Bali Town, Bali Loal Government Area, Taraba State, Nigeria. *Nig J Parasitol* 2014; **35**(1–2): 149-56.

[17] Bailey E. A comparison of the gastrointestinal parasites recovered from olive baboons (*Papio anubis*) and tantalus monkeys (*Cercopithecus aethiops tantalus*) in three habitats in Gashaka Gumti National Park, Nigeria [Dissertation]. London: Roehampton University; 2011.

[18] Handzel T, Karanja DM, Addiss DG, Hightower AW, Rosen DH, Colley DG, et al. Geographic distribution of schistosomiasis and soil-transmitted helminths in Western Kenya: implications for antihelminthic mass treatment. *Am J Trop Hyg* 2003; **69**(3): 318-23.

[19] Stothard JR, Kabatereine NB, Tukahebwa EM, Kazibwe F, Mathieson W, Webster JP, et al. Field evaluation of the Meade Readiview handheld microscope for diagnosis of intestinal schistosomiasis in Uganda school children. *Am J Trop Med Hyg* 2005; **73**(5): 949-55.

[20] Ajakaye OG. Intensity of urinary schistosomiasis in Obedum community of River State, Nigeria. *Nig J Parasitol* 2013; **34**(1): 47-50.

[21] Mathewos B, Alemu A, Woldeyohannes D, Alemu A, Addis Z, Tiruneh M, et al. Current status of soil-transmitted helminths and *Schistosoma mansoni* infection among children in two primary schools in North Gondar, North West Ethiopia: a cross-sectional study. *BMC Res Notes* 2014; **7**: 88.

[22] Amuta EU, Houmsou RS. Prevalence, intensity of infection and risk factors of urinary schistosomiasis in pre-school and school children in Guma Local Government Area, Nigeria. *Asian Pac J Trop Med* 2014; **7**(1): 34-9.

[23] Houmsou RS, Amuta EU, Wama BE, Hile TD, Bingbeng JB. Occurrence of malaria in children under five years: knowledge, attitudes and perceptions among mothers in a Nigerian semi-urban area. *J Sci Res Rep* 2014; **3**(8): 1127-34.

[24] Raso G, Matthys B, N'Goran EK, Tanner M, Vounatsou P, Utzinger J. Spatial risk prediction and mapping of *Schistosoma mansoni* infections among school children in western Côte d'Ivoire. *Parasitology* 2005; **131**(Pt 1): 97-108.