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Spatial distribution of soil-transmitted helminthiases and co-infection with schistosomiasis among school children in Nigeria

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ABSTRACT

Objective: To determine the spatial distribution of soil-transmitted helminthiases (STHs) and level of infection in relation to epidemiological factors, and to determine co-infection with schistosomiasis among school-aged children in Gashaka Local Area, Taraba State, North East, Nigeria.

Methods: Both urine and faecal samples were collected from school-aged children from January–June 2014. The samples were processed using standard filtration and formol-ether concentration techniques for urine and stools respectively. Remotely sensed images were processed using earth resource data analysis system 9.1 and ArcGis 9.2 softwares.

Results: A point prevalence of 11.0% (119/1080) was reported out of 1080 children examined. Hookworm infection had the highest infection (5.4%, 59/1080) followed by ascariasis (3.8%, 41/1080) and trichuriasis (1.7%, 19/1080). The spatial distribution of the individual helminths infection showed hookworm infection to be higher in Mayo-selbe (23.8%, 43/180), Gashaka (21.6%, 39/180) and Serti A (12.7%, 23/180) ($\chi^2 = 52.58$, $P = 0.000$). Ascariasis was higher in Serti A (6.7%, 12/180) and Gashaka (6.1%, 11/180) ($\chi^2 = 54.15$, $P = 0.000$), while trichuriasis was higher in Mayo-Selbe (7.2%, 13/180) ($\chi^2 = 54.15$, $P = 0.000$) than the other localities. Considering the overall STHs, localities such as Gashaka (30.0%, 54/180), Mayo-Selbe (23.8%, 43/180) and Serti A (19.4%, 35/180) were significantly infected than other localities ($\chi^2 = 93.68$, $P = 0.000$). The logistic regression model showed that low altitude (< 716 m) was significantly associated (odds ratio = 2.676, confidence interval = 1.981–3.615; $P = 0.000$) with STHs.

Conclusions: Though hookworm infection remains an important public health problem in the area, its infection levels varied between children's locations. The spatial distribution maps in this study are important and useful for planning, evaluating and implementing adequate control programmes for STHs among school-aged children.

1. Introduction

Soil-transmitted helminthiases (STHs) are among the most common parasitic infections that plague humans who live in poor resource countries of the world. Recent estimates showed that 1.45 billion people are infected with ascariasis, 1.3 billion with hookworm infection and 1.05 billion with trichuriasis[1]. Schistosomiasis still poses and remains a public health problem in many parts of developing

countries where there is inadequate supply of potable water. It is estimated that 249 million people are infected worldwide with schistosomiasis among which 90% live in sub-Saharan Africa[2].

It is estimated that more than 610 million school-aged children are at the highest risk of STHs and schistosomiasis with African school children living in rural areas and urban slums more exposed to the infections[3]. Both infections are highly associated with socioeconomic, climatic, poor hygienic and environmental conditions. These diseases caused severe adverse effects such as poor appetite, stunted growth, absenteeism in school and reduced cognitive performance among infected children[4-8].

Nigeria like most of the countries in sub-Saharan Africa has not

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achieved the Millennium Development Goals of accessing to safe drinking water and reducing by half of infections due to neglected tropical diseases. Taraba State is one of such States in North East Nigeria, where access to safe drinking water and sanitation in rural and urban slums is lacking. Local government areas (LGAs) such as Gashaka have made little progress within the concept of Millennium Development Goals to reduce STHs and schistosomiasis among school-aged children mostly due to limited financial resources. Majority of the inhabitants in the area still depend on ponds, streams and rivers for water consumption and daily chores activities. A high level of insalubrity among the inhabitants is also existing. During the past 5 years, the preventive chemotherapy such as praziquantel, the drug of choice for schistosomiasis and albendazole in treating STHs are administered yearly to reduce the burden of those infections among school-aged children. But these interventions were undertaken without proper guidance and prior epidemiological studies. Therefore, studies need to be carried out to provide guidance for efficient and cost-effective control programmes in the area. This study was conducted to determine the spatial distribution of STHs and level of infection in relation to epidemiological factors of school-aged children, as well as STHs infected children co-infected with schistosomiasis in Gashaka Local Government Area, Taraba State, North East, Nigeria.

2. Materials and methods

2.1. Study area

Gashaka LGA is located in the southeast of Taraba State between 11°00'–12°00' E and 7°30'–8°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, to the west by Kurmi and Bali LGAs. The area is in the typical Guinea Savannah zone of Nigeria with 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 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

A cross-sectional study was conducted between January-June 2014. Prior to the commencement of the study, ethical clearance and permission were obtained from the Directorate of Health of the Local Government Area. Headmasters of the selected primary schools were later 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 were drawn from all the 6 localities: Gashaka village, Garbabi, Kwagin, Mayo-Selbe, Serti A and Serti B. The population size in each school was calculated using the following formula at 0.05 significance level:

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

whereas, $p = 85\%$ is the estimated prevalence in the area, $Z_{1-\alpha/2} = 1.96$, $d^2 = 0.0025$. 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.

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.

2.4. Samples collection and laboratory procedures

About 20 mL of urine and 2 g of stool samples were collected from each child using labelled universal bottles. The urine samples were collected between 10:00 a.m and 14:00 p.m during the day each child brought his/her early morning stool for examination. All specimens were analysed within the premises of the school.

Urine samples were analysed 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 formal-ether concentration technique^[9]. Microscopic examinations were done by two independent experienced laboratory technologists. A third one who was blind to the first two examinations randomly selected some few positive slides for parasites confirmation. All examinations were done under 10 \times and 40 \times objective lenses of an Olympus microscope. No child was reported having both *Schistosoma mansoni* and *Schistosoma haematobium* infections.

2.5. Acquisition of elevation and mean annual rainfall datasets

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 \times 10 m and 1 km \times 1 km respectively.

2.6. Geographic information systems and image processing

All schools' geographic data 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 STHs 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 6 localities were mosaicked using earth resource data analysis system imagine 9.1 software (Earth Resource Data Analysis System Inc. Atlanta, GA, USA) to give a single image that incorporates the 6 localities. STHs spatial distribution map related to altitude and rainfall was produced by overlaying the map of the STHs 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 STHs between location, age, sex, level of education and occupation of parents. The binary logistic regression model was used to test possible relationship between spatial distribution of STHs and environmental variables such as altitude and mean annual rainfall.

3. Results

3.1. STHs in relation to epidemiological factors

Table 1 shows the prevalence of STHs among school-aged children in relation to epidemiological factors in Gashaka LGA, Taraba State, Nigeria. A point prevalence of 11.0% (119/1080) was reported out of the 1080 children examined. Hookworm infection had the highest infection (5.4%, 59/1080) followed by ascariasis (3.8%, 41/1080) and trichuriasis (1.7%, 19/1080). The sex-related prevalence of the overall STHs showed no significant difference between males and females (10.0% vs 12.1%) ($\chi^2 = 1.00$; $P = 0.316$). The age group (6–10) years had the highest prevalence of all STHs (12.6%, 78/618) though no statistically significant difference was observed between the various age-groups ($\chi^2 = 3.087$; $P = 0.378$). With regards to education and occupation of the children's parents, no significant difference was observed in the prevalence of STHs between children whose parents are educated (9.7%, 50/513) and non-educated (12.8%, 69/536) ($\chi^2 = 1.386$, $P = 0.239$) and those whose parents are farmers (11.9%, 65/544) and non-farmers (10.1%, 54/536) ($\chi^2 = 0.312$, $P = 0.576$).

Table 1

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

Variables	No. exam	Ascariasis	Trichuriasis	Hookworm	Total
Point prevalence	1080	41 (3.8)	19 (1.7)	59 (5.4)	119 (11.0)
Sex					
Male	570	13 (2.3)	13 (2.3)	31 (5.4)	57 (10.0)
Female	510	28 (5.5)	6 (1.2)	28 (5.5)	62 (12.1)
Age (years)					
1–5	108	5 (4.6)	4 (3.7)	3 (2.8)	12 (11.1)
6–10	618	31 (5.0)	10 (1.6)	37 (6.0)	78 (12.6)
11–15	340	5 (1.4)	5 (1.4)	19 (5.6)	29 (8.5)
> 15	14	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Education of parents					
Educated	513	20 (3.8)	5 (0.9)	25 (4.9)	50 (9.7)
Non-educated	536	21 (3.9)	14 (2.6)	34 (6.0)	69 (12.8)
Occupation of parents					
Farmers	544	22 (4.0)	13 (2.3)	30 (5.5)	65 (11.9)
Non-farmers	536	19 (3.5)	6 (1.1)	29 (5.4)	54 (10.1)

3.2. Spatial distribution of soil-transmitted helminths

The spatial distribution of the individual helminths infection showed that hookworm infection was significantly higher in Mayo-selbe (23.8%, 43/180), Gashaka (21.6%, 39/180) and Serti A (12.7%, 23/180) ($\chi^2 = 52.58$, $P = 0.000$) (Figure 1a). Ascariasis was higher in Serti A (6.7%, 12/180) and Gashaka (6.1%, 11/180) ($\chi^2 = 54.15$, $P = 0.000$) (Figure 1b), while trichuriasis was higher in Mayo-Selbe (7.2%, 13/180) ($\chi^2 = 54.15$, $P = 0.000$) than the other localities (Figure 1c). Considering the overall STHs, localities such as Gashaka (30.0%, 54/180), Mayo-Selbe (23.8%, 43/180) and Serti A (19.4%, 35/180) were significantly infected than other localities ($\chi^2 = 93.68$, $P = 0.000$) (Figure 1d).

3.3. Logistic regression and risk model maps of STHs in relation to environmental variables

Logistic regression was used after forward stepwise (likelihood ratio) method, the model predicted all the 119 having STHs with an overall accuracy of 90.9% among the infected and non-infected children (Table 2). The model also showed that low altitude (< 716 m) was significantly associated (odds ratio (OD) = 2.676, confidence interval = 1.981–3.615; $P = 0.000$) with STHs in Gashaka local government (Figure 2), while no association was observed between STHs distribution and mean annual rainfall (Figure 3). The estimated coefficients (intercept), the standard errors and the goodness of fit of the binary models are shown in Table 3.

Table 2

Logistic regression predicting presence and absence of STHs in different locations surveyed in Gashaka LGA based on environmental variables.

Observed schistosomiasis	Predicted schistosomiasis		Correct prediction (%)
	Negative	Positive	
Negative	0	961	0.0
Positive	0	119	100.0
Overall			90.9

Table 3

Coefficients and goodness of fit of the logistic binary regression model showing the presence and absence of STHs in schools surveyed in Gashaka LGA based on observed data of disease and environmental variables.

Variables	RC	SE	Wald	df	P	OD	CI for OD	
							Lower	Upper
Altitude	0.984	0.153	41.195	1	0.000	2.676	1.981	3.615
Rainfall	-0.321	0.533	0.362	1	0.547	0.726	0.255	2.062
Constant	-4.564	1.213	14.145	1	0.000	0.10	-	-

RC: Regression coefficient; CI: Confidence interval.

3.4. Co-infections of STHs and schistosomiasis

Table 4 shows co-infections of schistosomiasis in STHs infected school-aged children in Gashaka LGA, Taraba State, Nigeria. Generally, 25.4% (28/110) of the STHs infected children were co-infected with schistosomiasis. The schistosomiasis + hookworm co-infection (18.2%, 2/110) was more common among the children than schistosomiasis + ascariasis (5.4%, 6/110) and schistosomiasis + trichuriasis (18.2%, 20/110) co-infections. Mayo-Selbe (12.7%) had the highest hookworm

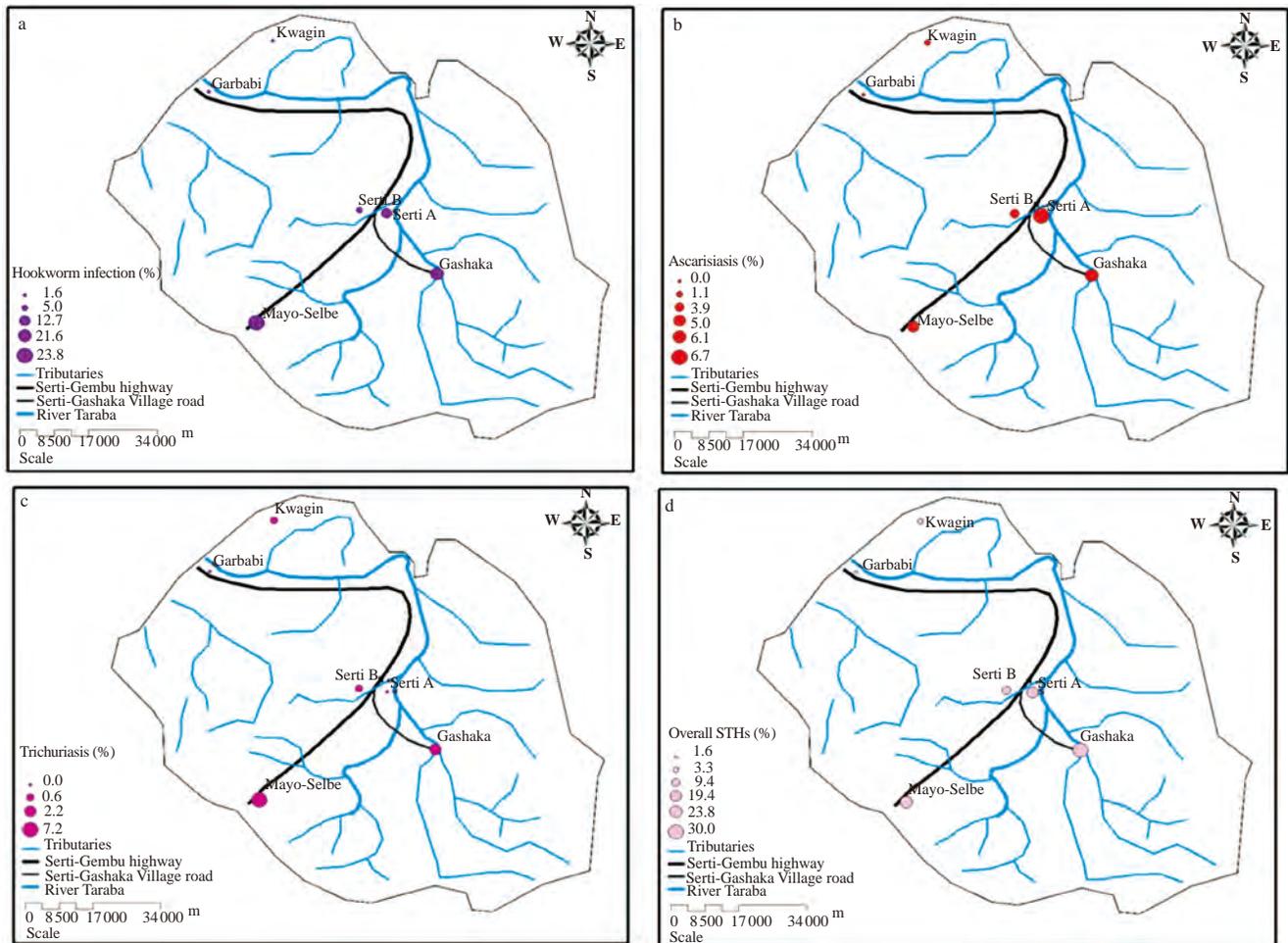


Figure 1. Spatial distribution of hookworm infection (a), ascariasis (b), trichuriasis (c), and the overall STHs (d) in Gashaka LGA, Taraba State, Nigeria.

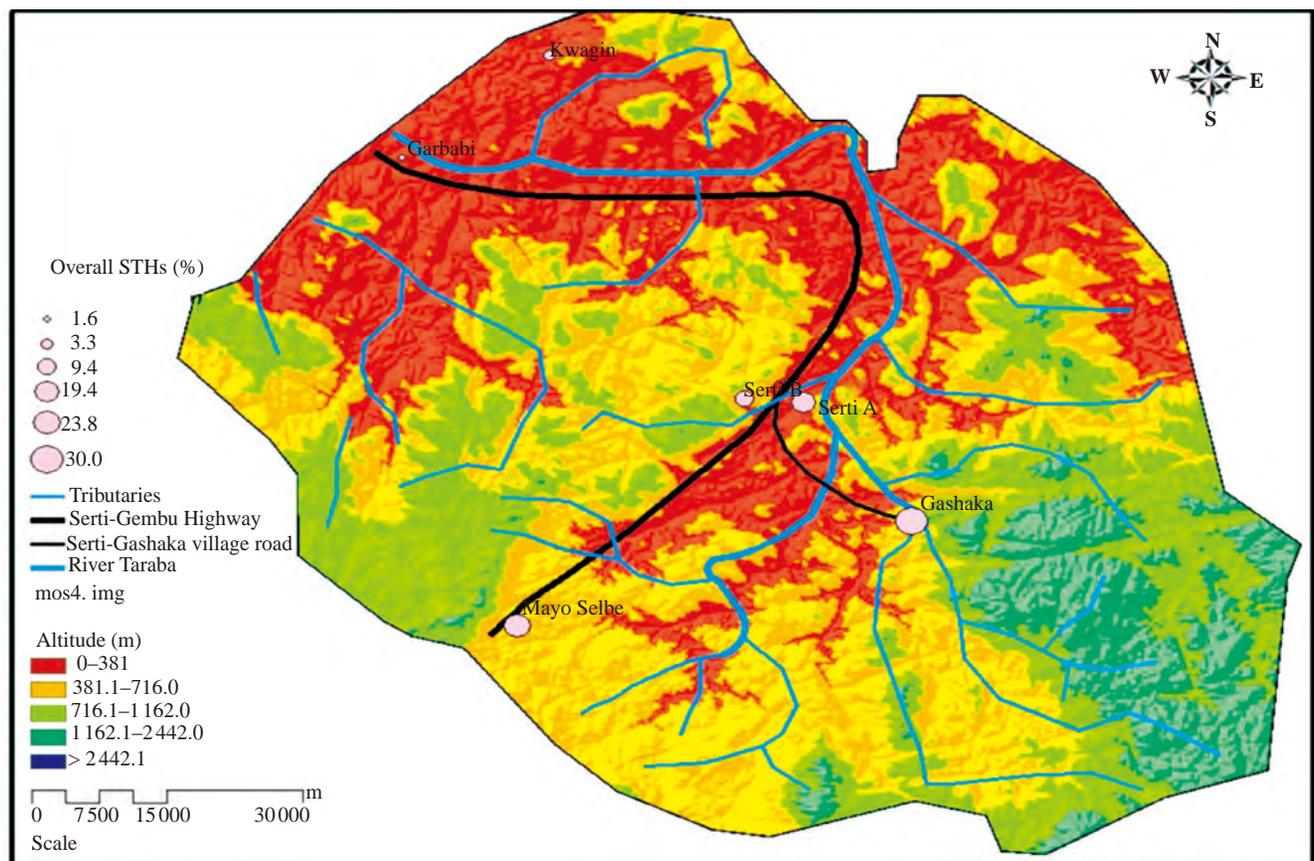


Figure 2. Spatial distribution of STHs in relation to altitude in Gashaka LGA, Taraba State, Nigeria.

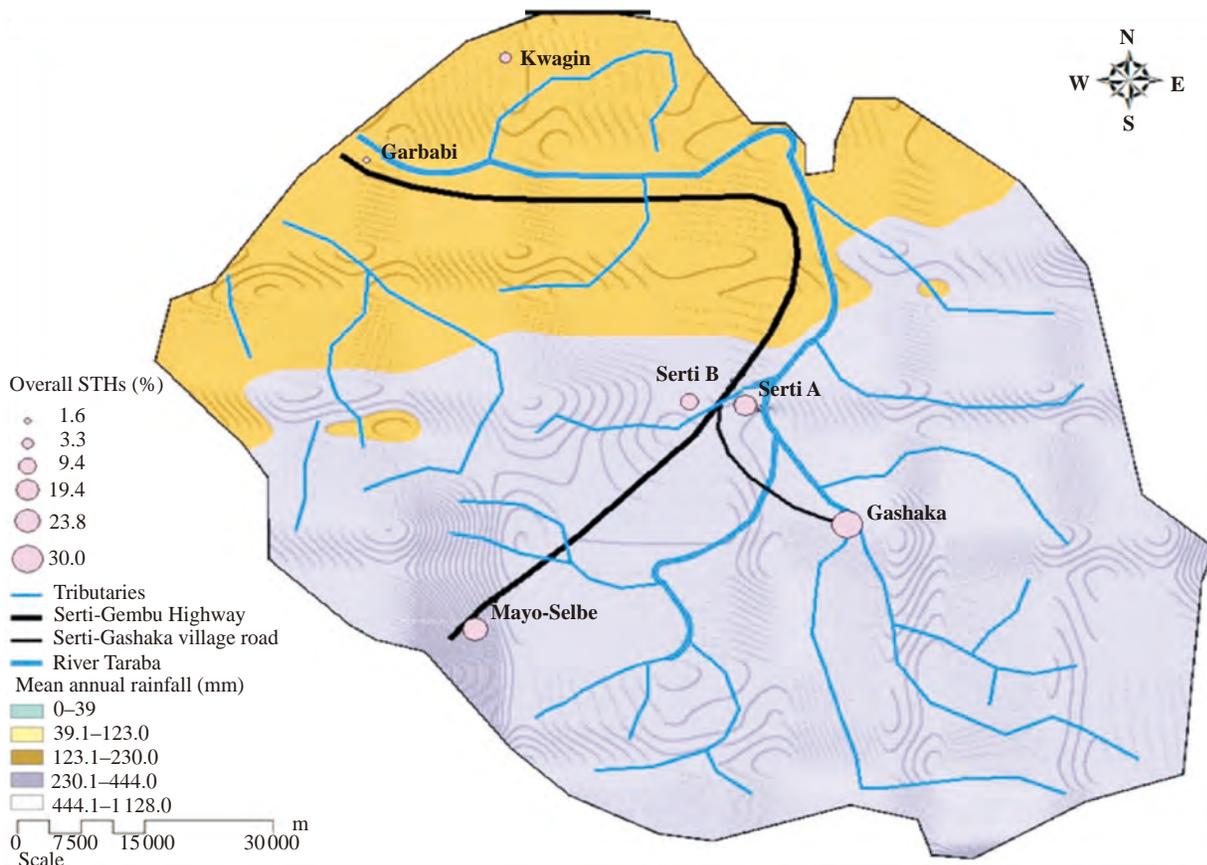


Figure 3. Spatial distribution of STHs in relation to altitude in Gashaka LGA, Taraba State, Nigeria.

+ schistosomiasis co-infections than the other localities ($\chi^2 = 7.97$; $P = 0.030$), but this was not significantly different between males and females (12.7% vs 5.4% ($\chi^2 = 0.992$; $P = 0.319$)). There was no significant difference of schistosomiasis + hookworm co-infection between: age groups (6–10) and (11–15) years (12.7% vs 5.4%, $\chi^2 = 0.378$, $P = 0.828$), children of educated and non-educated parents (12.7% vs 5.4%) ($\chi^2 = 2.681$, $P = 0.102$), as well as children of farmers and non-farmers parents (5.4% vs 12.7%) ($\chi^2 = 1.050$, $P = 0.306$).

Table 4

Co-infections of schistosomiasis in STHs infected school-aged children in Gashaka LGA, Taraba State, Nigeria. *n* (%).

Parameters	S + A	S + T	S + H
Overall	6 (5.4)	2 (1.8)	20 (18.2)
Wards			
Gashaka	0 (0.0)	0 (0.0)	0 (0.0)
Mayo-Selbe	2 (1.8)	2 (1.8)	14 (12.7)
Serti A	0 (0.0)	0 (0.0)	0 (0.0)
Serti B	4 (3.6)	0 (0.0)	8 (7.2)
Garbabi	0 (0.0)	0 (0.0)	0 (0.0)
Kwagin	0 (0.0)	0 (0.0)	0 (0.0)
Sex			
Male	6 (5.4)	0 (0.0)	14 (12.7)
Female	0 (0.0)	2 (1.8)	6 (5.4)
Age (years)			
1-5	0 (0.0)	0 (0.0)	0 (0.0)
6-10	6 (5.4)	0 (0.0)	14 (12.7)
11-15	0 (0.0)	2 (1.8)	6 (5.4)
> 15	0 (0.0)	0 (0.0)	0 (0.0)
Education of parents			
Educated	6 (5.4)	2 (1.8)	14 (12.7)
Non-educated	0 (0.0)	0 (0.0)	6 (5.4)
Occupation of parents			
Farmers	0 (0.0)	0 (0.0)	6 (5.4)
Non-farmers	6 (5.4)	2 (1.8)	14 (12.7)

S + A: Schistosomiasis + Ascariasis; S + T: Schistosomiasis + Trichuriasis; S + H: Schistosomiasis + Hookworm.

4. Discussion

To our knowledge, the present study provides the first spatially explicit distribution maps of STHs in Gashaka LGA, Taraba State, Nigeria. The overall infection level (11.0%) showed that the local government is a low-risk transmission area[1]. This low prevalence is perhaps the result of the scaling-up of deworming campaign by the government, non-governmental and international organizations such as World Health Organization and United Nations International Children’s Emergency Fund during the past 5 years. The approach used in the State was the integration of deworming campaign with other existing ones such as the polio eradication, onchocerciasis and lymphatic filariasis programmes. This integrative approach needs to be adopted by several other states of the federation for the control of major infections. The low infection level observed concurs with the STHs prediction map reporting most areas in Nigeria to be below 20%[10]. The infection level reported in this present study corroborates other studies reporting low infection level in some parts of Nigeria: 9.5% among school-aged children in Benin City, Edo State[11], 19.2% and 19.4% among school children in Port Harcourt and Sapele LGA of Rivers and Delta States respectively[12,13]. The present study reports a lower prevalence than that observed among school-aged children living in South Eastern Nigeria: 35.4% and 46.0% in Owerri West LGA and Akpo Community of Imo and Anambra States respectively[14,15]. The differences in infection levels of the latter

studies with the present study might be due to the fact that school children in those areas were yet to be administered albendazole as preventive chemotherapy for STHs. Recent reports showed that Nigeria has only attained 3% of its national coverage for preventive chemotherapy for STHs among school-aged children[1]. Hookworm infection was the commonest occurring STH among the school children. This goes along with the national trend that depicted hookworm infection as the leading STH in Nigeria[10]. In the study area, the presence of this infection might be associated with the sandy and moist nature of the soil which would have favoured the hatching of hookworm eggs to their subsequent larval development that penetrate skin thereby infesting the children as they were found to defaecate indiscriminately, working and walking barefooted. In contrast to the present study, the forecited studies and those carried out in Edo, Oyo and Osun States all located in the southern part of the country found ascariasis as the predominant STH in school children[11,16,17]. However, studies conducted in Makurdi and Kwande LGA, Benue State, North Central Nigeria reported hookworm as the most predominant species[18,19]. Differences in such helminths predominance could be attributed to the nature of the soils and climate which could differ in texture, moist and humidity respectively thereby favouring the hatching and survival of these respective parasites eggs in the environment. The climate of the central and southern part of North East Nigeria is more of Guinea Savannah with sandy soil and average humidity which can easily favour development of hookworm larvae than that of the southern part characterized by forest and high humidity. Observations from the present and forecited cross-sectional studies using parasitological surveys contrasted the Nigeria predictive map for hookworm which put South-East and South-West Nigeria at higher infection risk, while those forecited studies reporting ascariasis corroborate the ascariasis predicted map showing the south-western part of Nigeria at higher infection risk[10]. Another hypothesis could be the behavioural attitudes of the children who could not be aware of the hygienic measures used to prevent these infections, this can influence rapid re-infection even if they are dewormed regularly. Age did not influence infection pattern among children as all the age groups were similarly infected. This contrasts other studies that reported children aged 6-10 and 11-15 years having the highest burden of STHs than the 1-5 years[11,14,15,20,21]. Males and females were similarly infected, this reflects their common exposure to these parasites as reported in other studies[18,21].

Schistosomiasis and hookworm co-infection was found to be the commonest among the school children. This is a serious public health concern and might affect cognitive and nutritional status of the children in the area. Both infections have been reported to associate with anaemia thereby impairing the children's cognitive function through nutritional deficits such as iron imbalance in the body system[22-24]. The pattern of co-infection observed in this present study contrasts other studies that reported schistosomiasis

and ascariasis as the commonest co-infection among school-aged children[16,25].

Our predictive maps using environmental factors (altitude and rainfall) showed a relationship between STHs and altitude (< 716 m) in the area. This could be explained by the fact that most habitations in the area are clustered around the valley with high population density and no toilet facilities. Gashaka village and Mayo-Selbe localities are such areas where inhabitants defaecate openly in the nearby bushes. This observation agrees with the previous studies that reported aggregation of communities as sources of infection and transmission of STHs in endemic areas[26].

In conclusion, the spatial distribution maps of STHs in Gashaka LGA produced in this study are important and useful for planning, evaluating and implementing adequate control programmes for STHs among school-aged children. The study revealed that STHs and most particularly hookworm infection remain an important public health problem in the area though infection levels varied between children's location. It is therefore recommended that continued efforts for mass deworming campaign should be maintained on regular basis so as to significantly reduce the level of infection among the school-aged children. In locations such as Mayo-Selbe and Gashaka village where deworming campaign has not been consistent, there is an urgent need to put in place an integrated and effective control programme based on yearly drug administration for both STHs and schistosomiasis. Safe and clean water supply for drinking and domestic uses should be provided to inhabitants by the government and other non-governmental organizations so as to curb transmission and re-infection. There is a need for health education and community mobilization on the use of toilet facilities such as pit latrines in order to avoid indiscriminate defaecation.

Conflict of interest statement

We declare that we have no conflict of interest.

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