

# Spatial Distribution of Urinary Schistosomiasis (USCH) in a Rural Community in Oyo State, Nigeria

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## Research Article

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# Abstract

## INTRODUCTION

Schistosomiasis is a neglected tropical disease (NTD) of significant public health importance. Geographic Information System (GIS) identifies disease hotspots, vulnerable groups, and priority areas for resources. This study aimed to investigate the geographic distribution of urinary schistosomiasis and examine the link between proximity to water bodies and infection prevalence in the rural community of Otamokun, Nigeria.

## METHOD

A cross-sectional design was employed, recruiting 165 school-aged children (5–17 years old) through a multistage sampling approach. Data, including GPS coordinates, were collected via a questionnaire, and urine samples were analysed microscopically for *S. haematobium* eggs. Geospatial analysis using QGIS revealed a focal transmission pattern, with distinct clusters of high infection endemicity around the town hall, basic schools and Ipeba-Lagbedu Road, closely associated with the river network. A clear gradient showed prevalence decreasing with distance from the water.

## RESULTS

Statistical analysis found no significant association ( $\chi^2 = 2.35$ ,  $p = 0.13$ ) between household distance to the river ( $\leq 500\text{m}$  vs.  $>500\text{m}$ ) and individual infection status. This indicates that while environmental proximity defines geographical hotspots, individual risk is likely mediated by behavioural factors like water-contact patterns.

## CONCLUSION

The study concludes that effective control requires a multi-pronged strategy. This includes geographically targeting mass drug administration, snail control, and health education in high-risk zones, implementing school-based programmes, and addressing water-contact behaviour and sanitation. Sustained surveillance in low-endemic areas is also recommended to prevent the emergence of new transmission foci.

## INTRODUCTION

Schistosomiasis, also called bilharzia, is caused by parasitic trematodes of the genus *Schistosoma*. It is a neglected tropical disease (NTD) of significant public health importance, ranking second, after malaria, among major parasitic infections with socioeconomic and public health implications in tropical and subtropical regions. Over 250 million people around the world have schistosomiasis, and more than 90%

of these cases are in sub-Saharan Africa (Lai et al, 2015). Nigeria is recognised as one of the most endemic countries, with both *Schistosoma haematobium* and *S. mansoni* causing urinary and intestinal schistosomiasis, respectively prevalent across several ecological zones (Ezeh et al., 2019).

Schistosomiasis transmission often occurs when individuals come into contact with freshwater containing cercariae shed by infected intermediate snail hosts. Environmental and ecological factors that favor snail breeding, such as water temperature, vegetation, and flow patterns, are closely linked to the parasite's life cycle. Human activities, including bathing, swimming, fishing, washing, and irrigation, facilitate direct exposure to infested water, thereby maintaining the transmission cycle (Macy and Quick, 2009).

Geospatial information systems (GIS) answer questions about where diseases are prevalent, where populations at risk are located, and where resources are most needed to improve health outcomes (Gibson, 2023). Integrating GIS and spatial analysis tools into epidemiological research has enhanced the ability to identify high-risk zones and map infection clusters, as well as predict transmission dynamics based on environmental variables such as elevation, land usage, rainfall, and proximity to bodies of water. Moreover, understanding the geospatial distribution of schistosomiasis provides critical insights into how environmental and human behavioral factors interact to influence disease transmission. Such spatially explicit information is vital for evidence-based planning of control interventions, particularly in resource-limited settings where mass drug administration (MDA) and snail control programs must be geographically targeted for maximum efficiency (Monnier et al., 2020).

Global control of schistosomiasis emphasizes reducing disease prevalence through regular, targeted praziquantel treatment (WHO, 2022), and risk maps showing geographic patterns can guide policymakers in allocating limited resources efficiently (Luo et al., 2023). Countries such as China and the Philippines have successfully used GIS and remote sensing to identify environmental factors influencing disease spread, locate high-risk areas, and support local policy and planning for sustainable schistosomiasis control and prevention (Deol et al., 2019, Leonard et al, 2005 and Belizario et al., 2021). However, despite ongoing control efforts, schistosomiasis remains endemic in many Nigerian communities, largely due to persistent exposure to infested freshwater sources and uneven distribution of control measures. Traditional surveillance methods often overlook spatial heterogeneity in transmission risk, resulting in suboptimal intervention coverage (Nayak et al., 2025). A geospatial approach provides a clearer understanding of where and why transmission persists, enabling policymakers to prioritize high-risk communities for integrated control.

Proximity to water bodies remains a critical determinant of schistosomiasis transmission because the parasites' intermediate host snails are aquatic, and human contact with contaminated water is essential for infection to occur (WHO, 2026). Households located closer to rivers, ponds, or streams are more likely to engage in daily activities involving water contact, thus increasing their exposure risk. Several studies have shown that infection prevalence tends to decline with increasing distance from water bodies, typically beyond 500 meters (Alene et al., 2022, Gomes et al, 2025, Reitzug et al, 2023).

Nonetheless, variations existing in water-use patterns, exposure behaviour and local ecological conditions can significantly influence this relationship. This study, therefore, investigated the spatial distribution of schistosomiasis within the study community as well as examined the spatial relationship between household proximity to water bodies and schistosomiasis infection in the community. This is essential for identifying spatial clusters of risk and understanding the environmental determinants of disease persistence. This study will contribute valuable geospatial evidence to guide targeted control interventions, promote health education, and support policy formulation aimed at achieving schistosomiasis elimination in endemic communities. This study aimed to map and characterize the spatial distribution of urinary schistosomiasis infection in Otamokun, a rural community in Oyo State, Nigeria, to identify transmission hotspots and assess the relationship between proximity to water bodies and infection prevalence.

## Methods

### Research design

A cross-sectional study was conducted from July to September 2023 in Otamokun to identify households with children living with urinary schistosomiasis.

### Study setting

Ogo-Oluwa Local Government spans 369 km<sup>2</sup> and has an average temperature of 28°C. It features two main seasons, dry and wet, with an average humidity of about 57%. It borders Ejigbo LGA to the east, Oyo East and Afijio LGAs to the south, Ogo-Oluwa West LCDA to the north, and Oriire LGA to the west. The LGA comprises 10 political wards: Otamokun, Opete, Odo-oba, Ajaawa I, Ajaawa II, Ayede, Ayetoro, Idewure, Lagbedu, and Iwo-Ate. The 2006 census recorded a population of 65,184. Otamokun, one of the wards, is located at coordinates 7°57'0" N and 4°11'0" E. Farming is the predominant economic activity in the area, with residents involved in cattle and goat husbandry as well as crop farming. The region is crossed by seasonal rivers like Amuro, Owo, and Igbo, with Amuro being the largest and flowing around the community. These water bodies provide water for irrigation, grazing, and domestic use, while children frequently use them for fishing, fetching water, bathing, and swimming, particularly during the dry season. The area experiences both wet and dry seasons, with rainfall occurring primarily between March and October (Jaiyeola *et al.*, 2025).

Praziquantel, the medicine for schistosomiasis, was last distributed in the community three years before the data collection. Infected individuals were reported to the Oyo State Ministry of Health and the LGA's NTD team. Treatment was provided following national NTD guidelines for reporting and treatment of NTDs. School-age children who had lived in the study area for at least six months and did not receive any form of schistosomiasis treatment in the six months preceding the study were surveyed (Jaiyeola *et al.*, 2025).

### Figure I: Location Map of Study Area

**Study population:** The population surveyed comprised SAC and their caregivers

Using the sample size formula  $n = Z^2 p (1-p) / e^2$ , a total sample size of 165 was obtained. (Where,  $n$  denotes the sample size;  $Z = 1.96$  corresponds to the standard normal value for 5% Type I error;  $p = 9.5\%$  represents the prevalence reported in a previous study (Nduka et al., 2019); and  $e = 0.05$  indicates the error margin) (Jaiyeola et al., 2022)

**Sampling technique:** A multistage sampling technique was employed. Stage one was the purposive selection of Ogo-oluwa LGA from the four LGAs identified with moderate schistosomiasis endemicity in Oyo State, following the schistosomiasis and soil-transmitted helminths mapping (Nduka et al., 2019). In stage two, Otamokun Ward was selected from the ten wards in Ogo-Oluwa due to its high level of schistosomiasis endemicity. (Jaiyeola et al., 2022)

At stage three, households with eligible respondents were listed and mapped. This household listing was the sample frame from which every fourth household was chosen. At the final stage, the child who most frequently visited the river was surveyed in each selected household. Unique identification numbers were assigned to each household surveyed.

#### **Data collection instrument and data collection:**

Data were collected using a pretested semi-structured questionnaire scripted on the Kobocollect software. At the end of each interview, the geographic coordinates (latitude and longitude) were captured by the Kobocollect app and stored with the other data collected on the Android devices.

Mid-stream urine samples were collected from each child in labelled, clean 30-ml screw-cap containers between 10:00 a.m. and 2:00 p.m., the interval during which schistosome egg shedding is typically at its peak in infected persons. The urine samples were carried in cold boxes to the laboratory at Our Lady of Apostles Catholic Hospital, Oluyoro Oke Offa, Ibadan, Nigeria

#### **Data management and analysis**

All 165 urine samples underwent microscopy. About 10mls of each sample was centrifuged at 3000–4000 × g for about 10 minutes. The sediments from the centrifugation were analysed for *S. haematobium* eggs using 10x and 40x objective lenses and categorised as light (1–9 eggs per 10 ml) and moderate infections (10–49 eggs per 10 ml) [16]. Using the unique identification numbers assigned to the households and the children, the urine microscopy results of the child surveyed per household, whether positive or negative for schistosomiasis, were entered against the households. The data were put on the QGIS software, which was used to map the disease distribution in the community.

#### **Ethical approval**

This study was part of a broader epidemiological investigation examining the prevalence and factors associated with schistosomiasis in Otamokun, Oyo State, Nigeria, with approval received from the Oyo

## Results

The results showed a clear focal pattern of schistosomiasis transmission in Otamokun, with infection clusters and a gradient of endemicity, from high to low, particularly around the town hall and Ipeba-Lagbedu road. However, the statistical comparison of household distance to the river and individual infection status, as shown in Table 1, did not find a significant association ( $\chi^2 = 2.35$ ,  $p = 0.13$ ), despite a higher raw proportion of infections among those living farther away. This indicates that while environmental proximity to water bodies is spatially correlated with transmission hotspots, individual infection risk is likely mediated by other behavioural or ecological factors not captured by simple distance-based categorization.

The figure 2 below shows the geographical distribution of urinary schistosomiasis across Otamokun using 100m by 100m grids. Each grid shows the proportion of infected children in the area, that is, the percentage of children having positive test results from the urine microscopy: no endemicity (0%), low endemicity (0 - 10%), mild endemicity (10.1 - 25.0%), and high endemicity (25.1 - 40.0%). The map reveals distinct spatial variations in the endemicity of schistosomiasis within the study area, highlighting clear patterns of localized transmission. The highest levels of infection are concentrated within and around the town hall and the Ipeba-Lagbedu road particularly in areas situated close to the river network. Adjacent to these high-endemic zones are patches of mild endemicity, which form transitional zones between the high-risk areas and those with lower infection prevalence. Surrounding these zones are areas of low endemicity, creating a gradient that diminishes with increasing distance from the river. This spatial trend suggests that proximity to freshwater bodies plays a major role in sustaining transmission in the community.

In contrast, communities located further north, such as Asipa and Oguoo, display predominantly low or no endemicity, corresponding with their greater distance from the river and possible reduced frequency of human-water contact. The river network, shown in blue, runs close to the most endemic parts of Otamokun, supporting the hypothesis that schistosomiasis transmission in this area is closely linked to environmental factors, especially the presence of freshwater bodies that provide habitats for the intermediate snail hosts. These areas likely provide favorable ecological conditions, such as slow-moving or stagnant water for the breeding of *Bulinus* snails, which are essential to the life cycle of *Schistosoma haematobium*.

The spatial distribution also indicates that public facilities, including the Baptist Basic Schools, the Central Mosque, and the Town Hall, are situated within or near zones of mild to high endemicity. This proximity may expose school-aged children and community members who engage in recreational or domestic activities in nearby water sources to a higher infection risk. Given that school-aged children are the most vulnerable group in schistosomiasis transmission dynamics, these findings highlight the need for school-based preventive chemotherapy and health education programs.

Overall, the map demonstrates a focal pattern of schistosomiasis transmission, characterized by intense clustering of infection around water bodies and a rapid decline in prevalence with increasing distance from these sources. This pattern aligns with established epidemiological knowledge that schistosomiasis exhibits strong environmental dependence and localized transmission dynamics. These spatial insights provide essential evidence for optimizing control strategies and resource allocation for schistosomiasis elimination in the population. The findings imply that control measures should be geographically targeted, prioritizing high- and moderate-endemic zones in Otamokun for mass drug administration, snail habitat management, and behavioral interventions aimed at reducing human-water contact. Areas with low or no endemicity should be maintained under surveillance to prevent reinfection and monitor possible expansion of transmission foci.

**Figure 2 Geospatial distribution of schistosomiasis in Otamokun**

**Association between household proximity to river and prevalence of schistosomiasis**

Table 1 below shows the relationship between the proximity of respondents’ households to a water body and the occurrence of schistosomiasis infection among the study population. A greater proportion of households, 126 (76.4%), were located within 500 metres of a water body, while 39 (23.6%) were situated more than 500 metres away. Among those residing within 500 metres, 7 individuals (4.2%) were confirmed to be infected with schistosomiasis, compared to 5 individuals (3.0%) among those living more than 500 metres away. Infection appeared to be higher among households closer to the water body, but there was no significant association between proximity to the water body and schistosomiasis infection in the population studied ( $\chi^2 = 2.35, p = 0.13$ ). This suggests that, although proximity to the water body may influence the risk of infection, possibly due to more frequent contact with contaminated water during domestic, occupational, or recreational activities. The non-statistically significant association may be due to other factors, including water contact behaviour, sanitation practices, or snail distribution, which also play important roles in the infection transmission.

**Table 1: Association between the distance of respondents’ households to the river and Schistosomiasis prevalence**

| Distance of HH to water body (m) | Confirmed SCH |          | Total      | Sig  | $\chi^2$ |
|----------------------------------|---------------|----------|------------|------|----------|
|                                  | No (%)        | Yes (%)  |            |      |          |
|                                  | n = 153       | n = 12   | n = 165    |      |          |
| Near ≤ 500                       | 119 (77.8)    | 7 (58.3) | 126 (76.4) | 0.13 | 2.35     |
| Far >500                         | 34 (22.2)     | 5 (41.7) | 39 (23.6)  |      |          |

Table 1 presents a cross-tabulation analysis examining the relationship between the distance of respondents’ households from a water body and the prevalence of schistosomiasis. Out of a total of 165 respondents, the vast majority, 153 (92.7%), did not have schistosomiasis, while a small number, 12

(7.2%), were confirmed cases. The households are categorised into two groups based on proximity to the water body: those living near a water body ( $\leq 500$  meters) and those living far from a water body ( $> 500$  meters). The data shows that more than three-quarters of the respondents, 126 (76.4%) lived near a water body, and a slightly higher proportion of the schistosomiasis cases lived near a water body (7 out of 12 (58.3%). The statistical analysis suggests this observed association is not significant (Sig = 0.13,  $\chi^2 = 2.35$ ). Therefore, based on this data, we cannot conclude that the distance of a household to the river is a statistically significant factor in the prevalence of schistosomiasis among these respondents.

## Discussion

This study used QGIS to assess the spread of the disease in the study area and classified the endemicity into four categories of no (0%), low (1 - 10%), mild (10.1 - 25.0%), and high (25.1 - 40.0%), depending on the number of positive children found within a grid. The distance of the household from the river was not found to be significantly associated with schistosomiasis in the population studied. This result is in contrast to a study in Hunan and Jiangxi provinces of China, where the spatial distribution of schistosomiasis was significantly associated with distance to the nearest waterbody, and the prevalence of schistosomiasis decreased with increasing distance to the nearest waterbody in the study area. The non-significant association observed between proximity to a water body and schistosomiasis in the population studied may be because the predominant river- Amuro generally flows around the community, and children in the community were at equal risk. But by and large, the spatial distribution of schistosomiasis found in this study indicates parts of the community where schistosomiasis is more endemic than other areas and indicates where control efforts should be targeted.

Furthermore, the study findings showing the association between household proximity to the river and the risk of schistosomiasis align with those of a similar study that reported that individuals residing within 100–500 metres of a water source in endemic areas of Nigeria exhibited higher infection rates with *Schistosoma haematobium* (Ezeh et al., 2019). However, behavioural and environmental factors, such as the frequency of water contact, type of water source, and sanitation practices, contributed significantly to the overall transmission risk. Similarly, a study in Zambia demonstrated that proximity to water bodies increased the likelihood of infection but emphasized that exposure behaviour and ecological factors, including snail distribution, were critical determinants of disease prevalence (Simoonga et al., 2009). The absence of a statistically significant association in the present study may also reflect the influence of community-level exposure patterns, where multiple households use common water access points irrespective of distance. This uniformity in water contact could obscure the potential effect of the proximity of the household to the river. The findings underscore the importance of adopting an integrated approach to schistosomiasis control that combines behavioural interventions, improved water and sanitation infrastructure, and snail control measures, rather than focusing solely on spatial proximity as a predictor of infection risk.

## Conclusion

Based on the geospatial and statistical analyses, it can be concluded that while schistosomiasis transmission in Otamokun exhibits a clear focal pattern with high-infection clusters concentrated around the town hall, the schools and Ipeba-Lagbedu road, individual infection status is not significantly associated with household proximity to the river alone. The lack of a statistically significant relationship ( $\chi^2 = 2.35$ ,  $p = 0.13$ ) suggests that although environmental proximity to water bodies defines areas of higher transmission risk, actual infection is likely influenced by additional behavioural, ecological, or socio-demographic factors not captured by simple distance measures. Therefore, effective control strategies should combine spatially targeted interventions in high-risk zones with integrated approaches that address water contact behaviours, snail habitat management, and preventive health measures to reduce transmission.

## Recommendation

According to the findings of this research study, the following recommendations are proposed to optimize schistosomiasis control in Otamokun: it is recommended to implement a multi-pronged schistosomiasis control strategy in Otamokun that is both geographically and demographically targeted. This involves prioritizing mass drug administration, snail control, and health education in the identified high and mild endemicity zones, particularly around the town hall, the basic schools and Ipeba-Lagbedu road. School-based programs are crucial for protecting vulnerable children, while broader interventions addressing water-contact behaviour and sanitation are needed since proximity alone does not fully explain individual risk. Finally, sustained surveillance in low-endemic areas is essential to prevent the emergence or spread of new transmission foci.

## Declarations

Written informed consent was obtained from the parents, verbal assent was obtained from the children, and all information concerning the research was kept confidential.

## Declaration of Conflict of Interest

There are no potential conflicts of interest to disclose concerning the research, authorship, or publication of this paper.

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## Data availability statement

The dataset presented in the study is available on request from the corresponding author during submission or after publication. The data are not publicly available due to confidentiality.

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## Figures

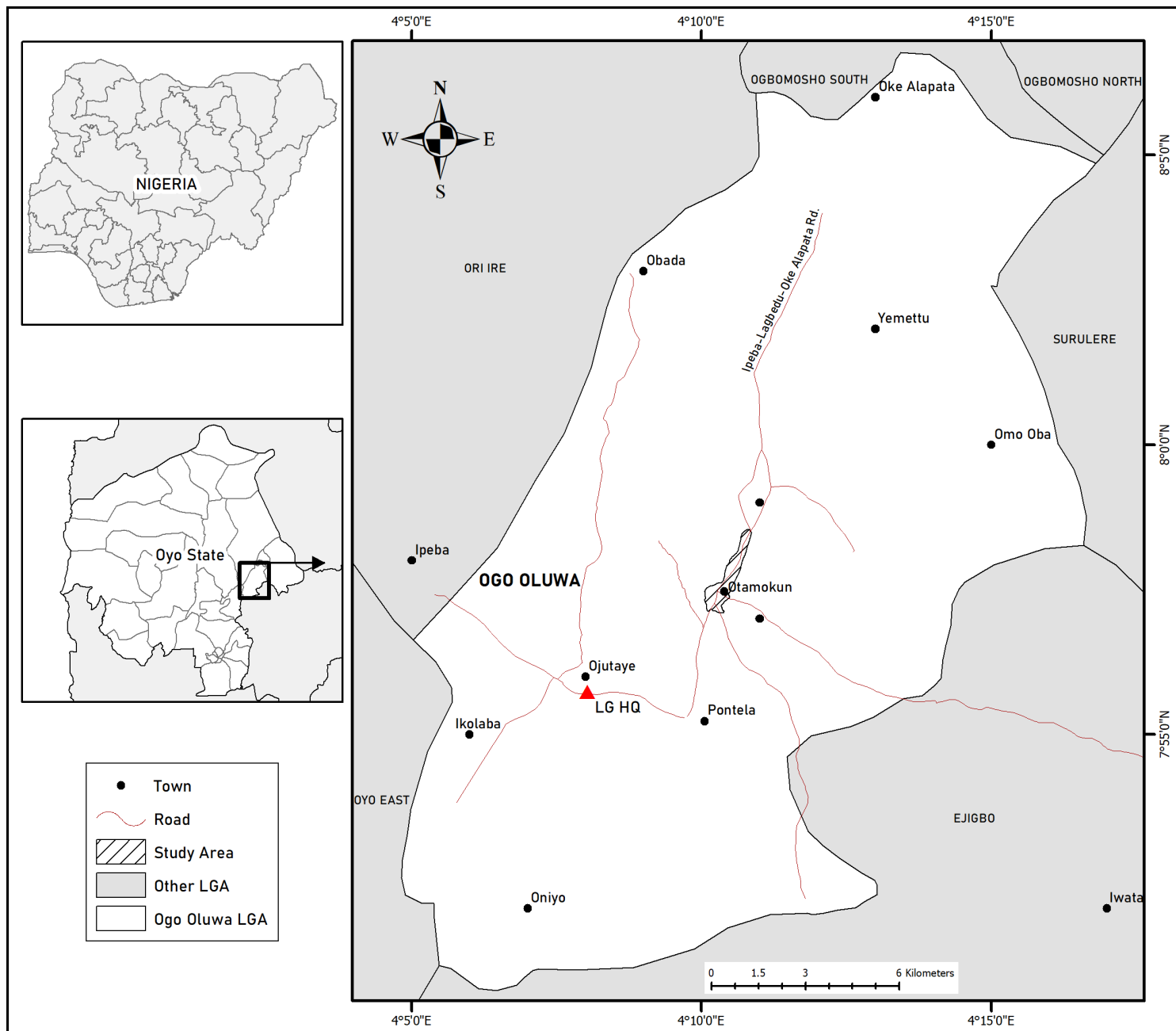


Figure 1

## Location Map of Study Area

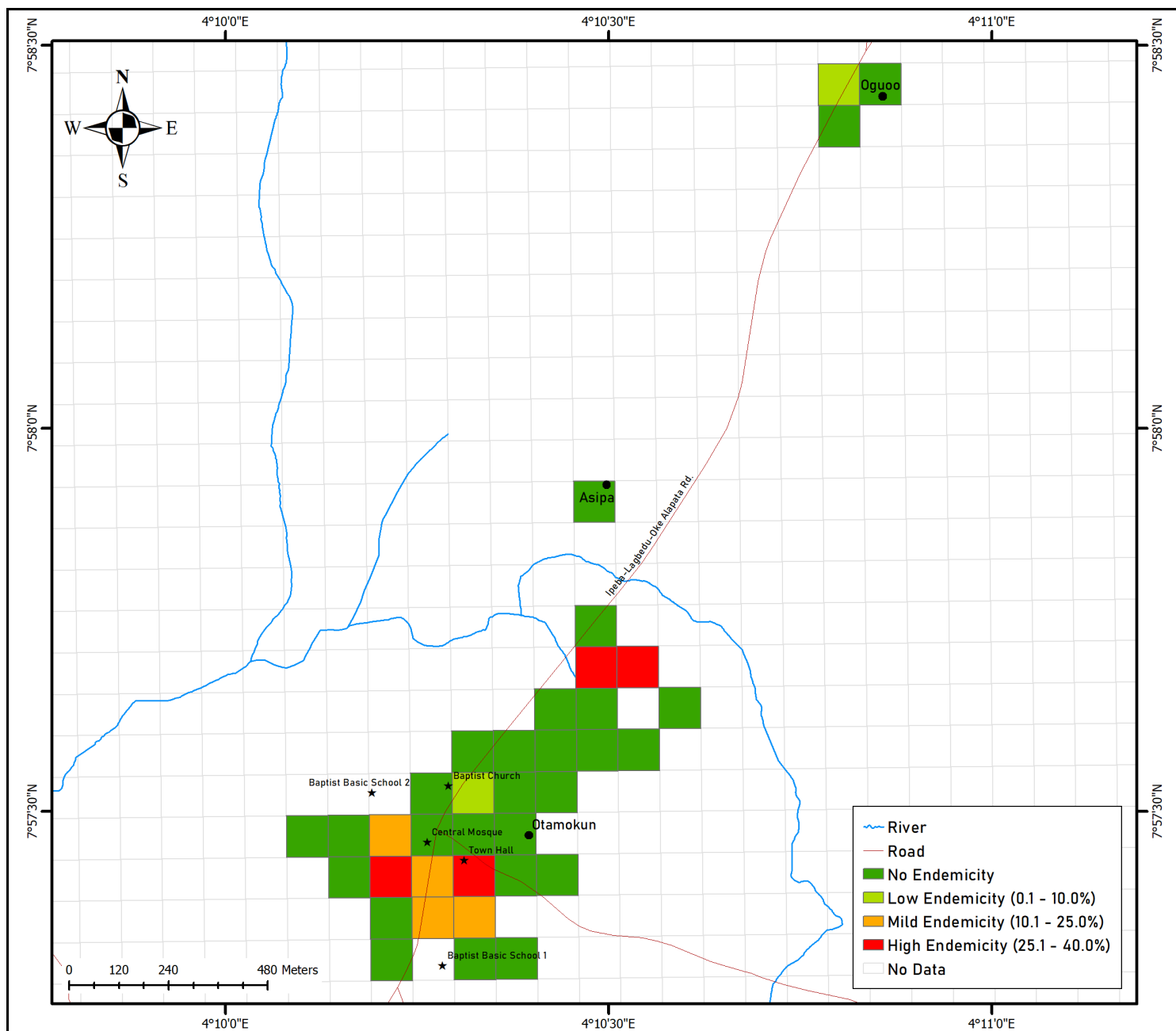


**Figure 2**

**Geospatial distribution of schistosomiasis in Otamokun**